Warracknabeal Energy Park

Warracknabeal Energy Park

Attachment A.8: Surface Water and Groundwater Assessment

Surface water and groundwater assessment

Warracknabeal Energy Park

Warracknabeal Energy Park Pty Ltd (WAEP)

22 March 2023

→ **The Power of Commitment**

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The Power of Commitment

Executive Summary

Surface Water

- The direct interface of any works with Yarriambiack Creek should be managed by setting a minimum setback of approximately 100 m from any infrastructure or works to the bank of creek, or outside of any mapped 1 in 100 year flood extent
- The siting of proposed infrastructure should avoid any direct interface of the various identified channels
- The surface water risks associated with flooding or impacting the downstream receiving waterway environments are generally low, including:
  - Changes to overland flow paths and major drainage paths, impacting the flow and regime of downstream waterways
  - Control discharge (pumping) from site sump storages to downstream receiving waterways impacting water quality
  - Uncontrolled discharge, as a results of stormwater runoff from site to downstream receiving waterways impacting water quality

Groundwater

- The windfarm project is underlain by a multi-aquifer system. The Loxton – Parilla Sands is interpreted to be the regional water table aquifer. The other aquifers are too deep to interact with the proposed development.
- There is very limited groundwater development in the region, which is potentially reflected by the generally brackish to saline nature of the water table aquifer. Fresher groundwater has, however, been mapped further to the south of the project area.
- Actively monitored State Observation Network bores indicate that the water table is relatively deep, and generally greater than 20 m below the surface in the region.
- The depth to groundwater would suggest that it does not discharge to waterways locally. Yarriambiack Creek is potentially an influent or losing waterway.
- Groundwater could be used an alternate water supply to service construction, however, the groundwater quality should be assessed against its proposed uses to confirm its suitability.
- The bulk of the project is to be constructed above grade and therefore direct interaction with the groundwater environment would be limited. The groundwater risks identified on the risk register were all classified as being low.
- Relevant controls to protecting groundwater during the construction and operation of the project are considered to be:
  - Preparation and implementation of a construction environment management plan
  - Existing controls under the *Water Act 1989* regarding the requirement of a technical hydrogeological assessment to support the licensing of groundwater take and use.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the Report.

Contents

Glossary **i**

1. Introduction **1**

1.1 Purpose of this report 1

1.2 Limitations 1

1.3 Scope of works 1

1.4 Assumptions 1

2. Legislative context **2**

2.1 Relevant legislation 2

2.2 Approvals 4

2.2.1 Surface water 4

2.2.2 Groundwater 4

3. Assessment method **5**

3.1 Overview 5

3.2 Links with other technical studies 6

4. Site characterisation **7**

4.1 Site location 7

4.1.1 Study area definition 7

4.1.2 Topography 7

4.1.3 Land use 7

4.1.4 Potentially contaminating land uses 9

4.2 Climate 9

4.3 Geological setting 10

4.3.1 Regional stratigraphy 10

4.3.2 Surface geology 11

4.3.3 Surface soils 11

5. Waterways and drainage **13**

5.1 Floodplain management 13

5.1.1 Drainage 13

5.1.2 Flood extents 15

5.1.3 Index of Stream Condition 17

5.1.4 Ramsar Sites 17

5.2 Yarriambiack creek flow 18

5.3 Water quality monitoring 19

5.3.1 Site specific 19

5.3.2 Waterwatch 19

5.4 Environmental values of waterways near the project 19

6. Hydrogeology **21**

6.1 Identified aquifers 21

6.2 Level of confinement 21

6.3 Groundwater management 21

6.3.1 Background to resource management 21

6.3.2 Relevant groundwater management area 22

6.4 Study area groundwater use 22
6.4.1 Data limitations 22
6.4.2 Bore use 22
6.4.3 Bore depths 24
6.5 Aquifer hydraulic parameters 24
6.5.1 Site specific 24
6.5.2 Regional mapping 24
6.6 Groundwater quality 25
6.6.1 Classification of groundwater 25
6.6.2 Groundwater quality indicators and objectives 26
6.6.3 Background salinity 27
6.6.3.1 Onsite bores 27
6.6.3.2 Regional mapping 27
6.6.3.3 Neighbouring bores 29
6.6.4 Environmental values 29
6.7 Groundwater potentiometry 30
6.7.1 Site monitoring 30
6.7.2 Regional mapping 30
6.7.3 State observation bores 32
6.8 Groundwater dependent ecosystems 36
6.8.1 Definition 36
6.8.2 GDEs in study area 36
6.9 Potential acid sulfate soils 39
6.9.1 Definition 39
6.9.2 Potential in study area 39
6.10 Conceptual hydrogeological model 41
7. Proposed development 43
7.1 Project description 43
7.2 Development activities and the water environment 43
7.2.1 Surface water 43
7.2.2 Groundwater 44
8. Water risk assessment 45
8.1 Existing conditions 45
8.2 Avoidance and design 45
8.3 Risk assessment 45
8.3.1 Overview of risk assessment method 45
8.3.2 Risk assessment process 45
8.3.3 Assigning a consequence level 46
8.3.4 Assigning a likelihood level 48
8.3.5 Assigning a level of risk 48
8.4 Risk register 49
8.4.1 Surface water 49
8.4.2 Groundwater 49

9. Impact assessment **53**
9.1 Discussion of surface water risks 53
9.1.1 Assessment of construction impacts 53
9.1.1.1 Impact to surface water quality (risk SW01, SW02, SW03, SW05) 53
9.1.1.2 Impact to drainage paths and surface water runoff (risk SW04) 54
9.1.2 Operation (and decommissioning) 54
9.1.2.1 Battery storages resulting in surface water contamination (risk SW06) 54
9.2 Discussion of groundwater risks 55
9.2.1 Assessment of construction impacts 55
9.2.1.1 Impact to groundwater quality (risk GW01, GW02) 55
9.2.1.2 Impact to existing users and depletion of groundwater resources (risk GW03) 55
9.2.1.3 Encountering unexpected shallow groundwater (risk GW04) 56
9.2.2 Operation (and decommissioning) 56
9.2.2.1 Battery storages resulting in groundwater contamination (risk GW05) 56
9.3 Climate change 57
9.3.1 Surface water 57
9.3.2 Groundwater 57
10. Summary of mitigation measures **58**
11. Conclusions **62**
12. References **63**

Table index

Table 1 Summary of State legislation 2
Table 2 Study area land use 7
Table 3 Summary of climate 9
Table 4 Generalised regional stratigraphy 10
Table 5 Driller’s Lithological log of Werrigar 1 (bore 102615) 11
Table 6 Index of stream condition: Yarriambiack Creek 17
Table 7 Environmental values of the Yarriambiack Creek 19
Table 8 Summary of bore use and bore yield information 22
Table 9 Summary of bore yield information 25
Table 10 Protected environmental values and groundwater segments 26
Table 11 Groundwater indicators and objectives 26
Table 12 Groundwater salinity 29
Table 13 Discussion of environmental values 29
Table 14 SON Bore summary 33
Table 15 Guide to consequence levels 47
Table 16 Guide to likelihood levels 48
Table 17 Risk matrix 48
Table 18 Risk rating acceptability 49
Table 19 Water Risk register 50
Table 20 Mitigation measures 59

Figure index

Figure 1	Overview of EES assessment framework	5
Figure 2	Project area	8
Figure 3	Study area Surface Geology	12
Figure 4	Surface Water and identified flow paths	14
Figure 5	1 in 100 Year Flood Extent	16
Figure 6	Yarriambiack Creek flows (at Murtoa)	18
Figure 7	Yarriambiack flow duration curve (discharge in ML/day)	18
Figure 8	Study area groundwater bores	23
Figure 9	Bore Total Depth Histogram	24
Figure 10	Water Table Salinity (mg/L)	28
Figure 11	Depth to Water Table (m)	31
Figure 12	State Observation Network monitoring bore locations	34
Figure 13	SON Hydrographs	35
Figure 14	Groundwater Dependent Ecosystem (GDE) – Aquatic	37
Figure 15	Groundwater Dependent Ecosystem (GDE) – Terrestrial	38
Figure 16	Potential Acid Sulphate Soil	40
Figure 17	Study area hydrogeological conceptualisation	42
Figure 18	Mitigation hierarchy	58

Glossary

Acronym	Definition
AASS	Actual Acid Sulfate Soil
AHD	Australian Height Datum
ANZG	Australian and New Zealand Guidelines
BOM	Bureau of Meteorology
CMA	Catchment Management Authority
CEMP	Construction Environment Management Plan
DELWP	Department of Land, Water and Planning
EC	Electrical Conductivity
EES	Environmental Effects Statement
EPA	Environment Protection Authority
EPBC	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)
ERS	Environment Reference Standard
GDE	Groundwater Dependent Ecosystem
GED	General environmental duty
GEDIS	Geological, Exploration and Development Information System
GIS	Geographic Information System
GMA	Groundwater Management Area
GQRUZ	Groundwater Quality Restricted Use Zones
GWMW	Grampians Wimmera Mallee Water
ISC	Index of stream condition
MNES	Matters of national environmental significance
NEPM	National Environment Protection Measures
PASS	Potential Acid Sulfate Soil
RAMSAR	Convention on Wetlands of International Importance Especially as Waterfowl Habitat
SON	State Observation Network
SWL	Standing Water Level
TDS	Total Dissolved Solids
VAF	Victorian Aquifer Framework
WMIS	Water Measurement Information System
WWTP	Wastewater Treatment Plant

1. Introduction

1.1 Purpose of this report

GHD Pty Ltd (GHD) was engaged by Warracknabeal Energy Park Pty Ltd (WAEP) to complete a surface and groundwater assessment for the proposed Warracknabeal Energy Park. The objective of the works was to provide information regarding the water environment that could support planning referrals and applications.

1.2 Limitations

This report: has been prepared by GHD for Warracknabeal Energy Park Pty Ltd (WAEP) and may only be used and relied on by Warracknabeal Energy Park Pty Ltd (WAEP) for the purpose agreed between GHD and Warracknabeal Energy Park Pty Ltd (WAEP) as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Warracknabeal Energy Park Pty Ltd (WAEP) arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

GHD has prepared this report on the basis of information provided by Warracknabeal Energy Park Pty Ltd (WAEP) and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.3 Scope of works

The scope of works was documented in GHD proposal 12586770-246146-10 issued 22 June 2022. The groundwater and surface water assessments are to include:

– A review of the existing surface water and groundwater conditions
– Development of a water risk register
– Assessment of potential impacts arising from the proposed windfarm development on the water environment.

1.4 Assumptions

This investigation has relied on a number of data sources including:

– Published geological and hydrogeological mapping
– State drilling records: GEDIS (Geological, Exploration and Development Information System), WMIS (Water Management Information System)
– Government produced literature including land use planning information, meteorological, and topographical data
– GIS layers supplied by WAEP.

These data sources have been referenced, where relevant, throughout this report. A complete list of references is provided in Section 12 of this report.

2. Legislative context

2.1 Relevant legislation

A summary of the key Federal and State legislation relevant to the water environment is provided in Table 1.

Table 1 Summary of State legislation

Act	Description	Relevance to project
Water Act 1989 (Victoria)	In the context of groundwater, the *Water Act 1989* principally deals with the sustainable, efficient and equitable management and allocation of the resource. It also provides a means for the protection and enhancement of all elements of the terrestrial phase of the water cycle.	A licence is required to construct works on a waterway or to abstract groundwater.
Environment Protection Act 2017 (Victoria)	The *Environment Protection Act 2017* empowers the Environment Protection Authority Victoria (EPA Victoria) to implement regulations, and protect the environment from pollution and the management of wastes. The Act regulates the discharge or emission of waste to water, land or air by a system of Works Approvals and licences. It has the objectives of preventing and managing pollution and environmental damage, and the setting of environmental quality goals and programs. No groundwater approvals are required under the *Environment Protection Act 2017*.	The cornerstone of the 2017 Act is the General Environmental Duty (GED). GED is defined as "a person who is engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste must minimise those risks, so far as reasonably practicable". To comply with GED, the project must: – Identify and assess risks to human health or the environment posed from an activity – Assess options to eliminate and reduce risks – Implement controls to reduce risks The EP Act is supported by subordinate legislation, including regulations and the Environment Reference Standard (ERS). The ERS: – identifies environmental values that the Victorian community want to achieve and maintain – provides a way to assess those environmental values in locations across Victoria – has indicators and objectives to measure people's actions against these values. The indicators and objectives set out in the ERS will be used as a standard to measure any potential impacts of the project on environmental values. Other guidelines documents provide guidance on how the project can comply with the GED, including: – About Stormwater (EPA Victoria 2020a) – Civil construction, building and demolition guide. (EPA Victoria 2020b) – Managing soil disturbance. (EPA Victoria 2020c) – Managing stockpiles. (EPA Victoria 2020d) – Working within or adjacent to waterways. (EPA Victoria 2020e) – Managing truck and other vehicle movement. (EPA Victoria 2020f)

Act	Description	Relevance to project
Environmental Effects Act 1978 (EE Act) (Victoria)	The *Environment Effects Act 1978* provides for assessment of proposed projects that are capable of having a significant effect on the environment. The Act enables statutory decision-makers (Ministers, local government and statutory authorities) to make decisions about whether a project with potentially significant environmental effects should proceed. The Act enables the Minister administering the *Environment Effects Act* to decide that an Environment Effects Statement (EES) should be prepared. The EES process involves: – Referral to the Minister for Planning – The Minister's decision on the need for an EES – Preparation of scoping requirements for the EES studies and reporting – Preparation of the EES report – Public review (exhibition and lodgement of submissions) – Ministerial assessment of environmental effects – Consideration of the assessment	At the time of preparation of this report it is understood that the project has not been submitted for EES referral. This report assesses the potential surface water, groundwater and geotechnical impacts associated with the project to inform the preparation of the project's EES referral.
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (Federal)	The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) promotes the conservation of biodiversity by providing protection for threatened species, threatened ecological communities, migratory and marine species and other protected matters. The Australian Government Department of Climate Change, Energy, the Environment and Water administers the EPBC Act.	This is relevant where there are EPBC Act listed species in waterways within the project study area. Warracknabeal Energy Park Pty Ltd has advised that a separate flora and fauna assessment has been commissioned which will include an assessment of matters relevant to the EPBC Act.
National Environment Protection Council Act 1994 (NEPC Act) (Federal)	The NEPC Act resulted in the establishment of the National Environment Protection Council (NEPC) and National Environment Protection Measures (NEPMs). NEPMs are a set of national objectives designed to assist in protecting or managing particularly aspects of the environment. A NEPM was established for the Assessment of Site Contamination (ASC) (NEPC 1999) which was amended in 2013. The NEPM (ASC) provides a national approach to provide adequate protection of human health and the environment, where site contamination has occurred, through the development of an efficient and effective national approach to the assessment of site contamination. No approvals are required under the NEPM Act.	This is considered a relevant guideline where contaminated groundwater (and water, land, air) may be encountered by the project.

2.2 Approvals

This project may require an Environment Effects Statement (EES) under the *Environment Effects Act 1978* (EE Act). The EES and/or planning permit application will inform assessment of approvals required for the project including under the *Environment Protection and Biodiversity Conservation Act 1999* and the *Water Act 1989.*

2.2.1 Surface water

The Wimmera Catchment Management Authority (CMA) has statutory responsibilities under the *Water Act 1989* to monitor, manage and administer control over works which may impact upon designated waterways. To ensure the health of waterways is not adversely effected, works and activities within the bed and banks of designated waterways require approvals (Works on Waterways Permit). All works on waterways are subject to the *Aboriginal Heritage Act 2006* and must comply with the Aboriginal Heritage Regulations (2007).

2.2.2 Groundwater

The following approvals are required for the groundwater environment:

– Licence to construct a bore (greater than 3 m deep)
– Licence to take and use groundwater

3. Assessment method

3.1 Overview

This section describes the method that is common to each of the surface water and groundwater assessments. A risk-based approach was applied to prioritise the key issues for assessment and inform measures to avoid, minimise and offset potential effects (refer Figure 1).

The approach used in the assessment has been guided by an evaluation framework that is broadly consistent with what would be required under an EES. At the time of preparation of this document, the project has yet to be referred to the Victorian Minister for Planning and therefore the requirement or otherwise for an EES has not been formally established. Furthermore, separate referrals in relation to the matters of national environmental significance (MNES) have not been made.

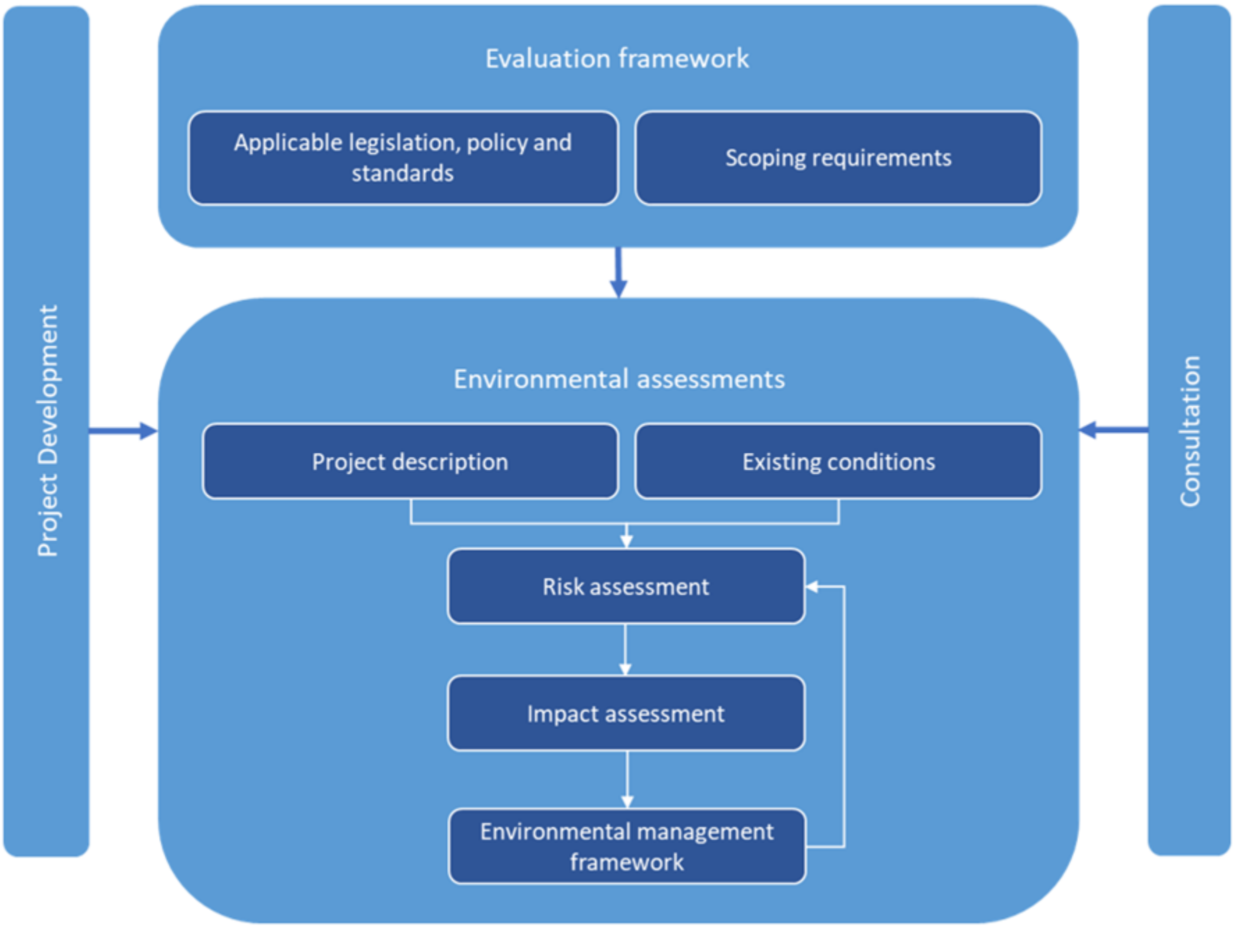


Figure 1 Overview of EES assessment framework

An effective impact assessment should:

- Be consistent with the principles of a systems and risk-based approach
- Put forward a sound rationale for the level of assessment and analysis undertaken for any environmental effect or combination of environment effects arising from all components and stages of the project

The surface water and groundwater assessment undertaken encompasses consideration of physical systems, ecological systems, human communities, land use effects and economic effects as relevant to the project. It has been undertaken using a precautionary approach according to the following steps:

- Characterisation of the existing environmental conditions.
- Review of the Project design and the proposed construction and operation activities in the context of the existing conditions to determine the location, type, timing, intensity, duration and spatial distribution of Project components and activities in relation to sensitive receptors.
- An initial risk assessment to evaluate the likelihood and consequence of the proposed Project activities in the context of the initial mitigation measures to determine the relative importance of environmental risks associated with the Project.
- Assessment of potential direct and indirect environmental impacts to analyse the spatial and temporal extent, magnitude and nature of the potential impacts giving consideration to the sensitivity and significance of affected receptors.
- Evaluation of the predicted outcomes against applicable legislation, policy and standards.
- Evaluation of the potential for cumulative impacts caused by impacts of the Project in combination with impacts of other projects that are taking place or are proposed nearby.
- Identify mitigation measures where necessary, to address potentially significant environmental effects.
- Identification and evaluation of the residual environmental effects including magnitude, duration and extent, taking into account the proposed mitigation measures and their likely effectiveness.

Based on the findings of the surface and groundwater assessment, mitigation measures may have to be established to monitor and evaluate environmental management and contingency measures in relation to the residual environmental effects. These are described in section 10.

3.2 Links with other technical studies

This report has been prepared independently to flora and fauna studies being commissioned by WAEP. The following is noted regarding specific environmental values which have interdependencies with these other studies:

- Groundwater dependent ecosystems (GDEs):
  It is assumed that these other studies describe potential impacts to GDEs in terms of native vegetation removal within GDEs as well as impacts to existing groundwater flow pathways e.g. exposure of seeps / springs which negatively impact ecosystem health. The groundwater impact assessment conducted and documented in this report has concluded that all residual risks to groundwater are Very Low and that the project is not likely to significantly change groundwater levels, the flow of the springs or to alter the groundwater quality, prior to its discharge and expression at the surface.
- Aquatic values – this report does not characterise the existing aquatic habitats and does not undertake an assessment of the potential for direct loss of, or degradation to, habitat for aquatic species.

4. Site characterisation

4.1 Site location

The Warracknabeal Energy Park is a wind farm project located in the Yarriambiack Shire, 40 km north of Horsham. The proposal covers approximately 26,500 ha, west of the nearby township of Warracknabeal. The Yarriambiack Creek flows through Warracknabeal, fringed with river gums of the Warracknabeal Streamside Reserve.

4.1.1 Study area definition

The project area has been shown in Figure 2 (defined by a red boundary). As groundwater and surface water catchment processes occur on a larger scale, a much larger area, defined by a buffer zone of 5 km around the project area was used to define the study area.

4.1.2 Topography

The topography of the study area is essentially flat, and lies between 110 m and 120 m above sea level.

4.1.3 Land use

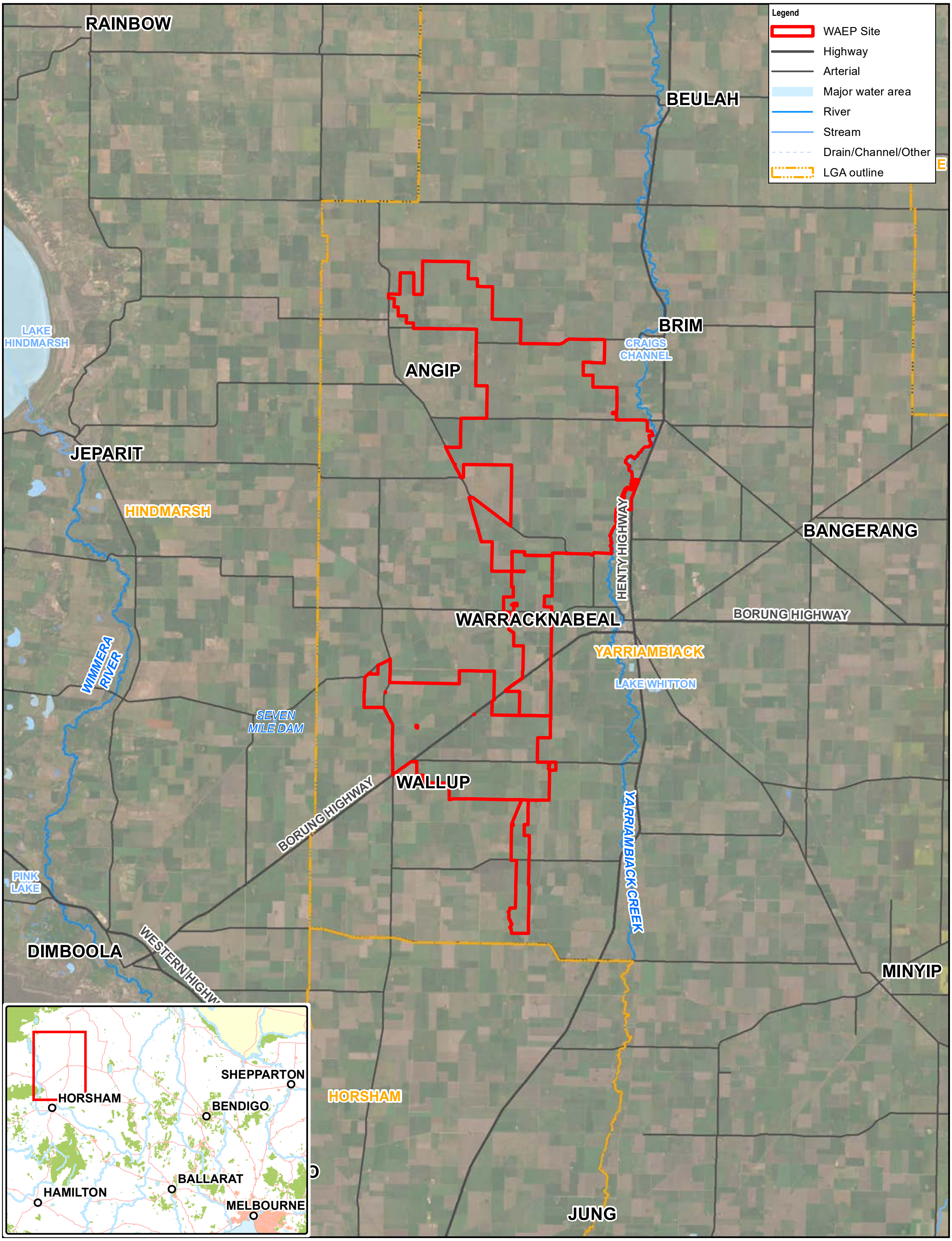
Lying within the northern Wimmera/southern Mallee, the study area is predominantly used for agricultural practices. Most land is used for either broad acre cropping or livestock grazing (mostly sheep).

Wooded vegetation is sparsely scattered across the project zone, and it is mainly limited to the river gums within the riparian zone of the Yarriambiack Creek, bordering the project outline. The northern area of the project zone abuts Yarriambiack Creek, while the southern area of the project is located approximately 5 km west of the creek. Limited vegetation can also be found along roads and on crown land areas.

A summary of the surrounding land uses and potential risks to water quality is included in Table 2.

Table 2 Study area land use

Direction	Land use activity	Potential water quality risks
North-South West-East	Zoned farming land (FZ)	Application of fertilisers, weedicide /herbicide Livestock manure Fuel and oil leaks from farm machinery Use of recycled water
East	Rural Living Zone (RLZ) General Residential Zone (GRZ) Public Use Zone (PUZ3) Industrial Zone (IN1Z) Commercial Zone (C1Z) Public Parks & Recreation (PPRZ)	Leakage of nutrient / organic rich matter from WWTP lagoon storages Contamination from leachate Water Treatment Plant I and Transfer Station (NE)



Paper Size ISO A4

0 2 4 6 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Project No. 31-12586776
Revision No. 1
Date 21/03/2023

Warracknabeal Energy Park Location

FIGURE 2

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Print date: 21 Mar 2023 - 09:20

Data source: VicMap, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: lgomez

4.1.4 Potentially contaminating land uses

A review of DELWP's Victoria Unearthed GIS mapping tool was undertaken to identify any EPA registered sites, specifically:

- EPA priority sites
- EPA licensed sites
- Sites subject to statutory Environmental Audit or Statements of Audit
- Landfills
- Groundwater Quality Restricted Use Zones (GQRUZ)

Two EPA licensed sites were identified in the area of interest:

- The Warracknabeal Water Treatment Plant (WWTP), which is located in the southern edge of town, next to the Henty Highway, 5 km east of the site.
- The Warracknabeal Transfer Station, situated next to Warracknabeal Race Course, 6 km east of the site. The transfer station is operational and treats putrescible waste and solid inert waste.

Most of the areas surrounding the project site are used for farming such as broad-acre cropping, while some other nearby areas are used for grazing of livestock which can result in faecal contamination and nutrient (e.g. nitrogen and phosphorous) run-off to water ways or fluxes to groundwater. Such land use practices are undertaken widely throughout Victoria. No feedlots were identified.

4.2 Climate

Climate data was obtained from the Bureau of Meteorology's Warracknabeal climate station (78000). The mean rainfall data, based on those years since 1900, is summarised in Table 3 for these stations, which indicates an average annual rainfall of around 363 mm occurs in this region. Evaporation far exceeds the annual rainfall.

Table 3 Summary of climate

Month	Long Term (1900-2022)		Short term (1990-2022)	
	Monthly rainfall (mm)	Monthly Evaporation (mm)	Monthly rainfall (mm)	Monthly Evaporation (mm)
January	19.5	255.6	22.3	255.0
February	23.3	210.7	21.2	205.6
March	21.5	169.8	15.8	168.8
April	23.8	99.3	21.6	98.8
May	39.0	56.4	36.4	56.3
June	39.8	36.9	45.4	37.0
July	39.3	41.5	38.7	41.0
August	40.6	61.2	39.6	62.0
September	40.0	90.9	40.3	93.1
October	36.5	139.0	31.5	142.9
November	27.6	182.6	30.5	184.1
December	23.7	234.8	25.4	233.4
Annual	373.5	1565.3	363.6	1556.2

Note:
1. Site elevation: 116 m.
2. Station location: Lat: -36.3575, Long: 142.3339.
3. Based upon data from 1889 to 2022.
4. Long term evaporation data from 1970 to 2020

4.3 Geological setting

4.3.1 Regional stratigraphy

The site is located within the Murray Basin, a structurally controlled sedimentary basin which has been filled with Tertiary aged marine and non-marine sediments, and which are overlain in many locations by Quaternary aged aeolian, fluvial and lacustrine sediments. The depth of the sediments can extend to around 400 m, and rest unconformably upon a Palaeozoic basement.

Understanding the depositional history of the basin is important to identifying the aquifers and their character throughout the basin. The Murray Basin can be split into three main depositional sequences (lower and middle Tertiary, and upper Tertiary/Quaternary) which correlate with periods of sea level rise and fall.

The earliest deposition occurred during the early Tertiary with the deposition of the fluvial Renmark Formation which has been further differentiated into the Warina Sands (older) and Olney Formation (younger). The second sequence occurred during the mid Tertiary, when sea level rises resulted in the inundation of parts of the western areas of the Murray Basin. Marls and limestones were deposited in the western areas (Murray Group), and clays (Geera Clay) in shallow marginal-marine conditions.

The third depositional sequence occurred during the upper Tertiary and involved a series of marine transgressions and regressions. Clays were deposited in the marine areas (i.e. overlying the Murray Group), and sands deposited in fluvial and fluvio-lacustrine environments further inland to the east (i.e. Loxton – Parilla Sands and Calivil Formations). Tectonic uplift dammed the Murray River drainage system and formed Lake Bungunnia, resulting in the deposition of the clays in the western areas, and fluvial – lacustrine sediments of the Shepparton Formation in the eastern areas.

Geologically recently there was a period of aridity and salinisation. Aeolian erosion and deposition led to the development of extensive dunefields and calcrete formation. Such is typically represented by east – west orientated linear dunes of the Woorinen Formation. The Woorinen Formation is a weathered, calcareous reddish brown clayey sand and sandy clay. Shepparton Formation sediments were reworked in drainage lines to form the Coonambidgal Formation, which is laterally restricted to present day waterways.

A summary stratigraphy is provided in Table 4. The mid-Tertiary Murray Group has not been included in the stratigraphy as it is absent beneath the study area. The marine sequences lie approximately 35 km to the west of the study, with the former coast approximating a north south line to the west of Dimboola and Jeparit.

Table 4 Generalised regional stratigraphy

Period	Epoch	Formation/Group	Lithology
Quaternary	Holocene	Alluvium Coonambidgal Formation	Lagoon and swamp deposits, silt, clay. Fluvial, lacustrine clay, sand, sandy clay.
	Holocene to Pleistocene	Yamba Formation	Aeolian lunette dune deposits, sand, silt, clay
	Pleistocene	Shepparton Formation	Fluvial silts, sands, sandy clay, and minor gravels
		Lowan Formation	Aeolian fine to medium grained dune sands
Tertiary	Pliocene to Miocene	Parrilla Sand	Very fine to coarse grained sands, silty sands, silts, with sandy conglomerates and micaceous clays
	Oligocene to Middle Miocene	Geera Clay | Winnabool Fm	Carbonaceous clays, calcareous clay, marls with minor silts
	Eocene	Renmark Group	Marginal marine and fluvial silts, sands, clays, and minor brown coal
Pre-Tertiary	Late Silurian to Devonian	Grampians Group	Siltstones and quartz sandstones basement

4.3.2 Surface geology

The surface geology at the site is presented in Figure 3. The Tertiary Loxton-Parrilla Sand is the main outcropping unit throughout the area of interest. There are occasional dune features (Woorinen Sands). A lithological profile can be interpreted from a deep Mines Department bore (Werrigar 1 – bore 102615) drilled on the northwestern outskirts of Warracknabeal township. Its lithological log has been summarised in Table 5.

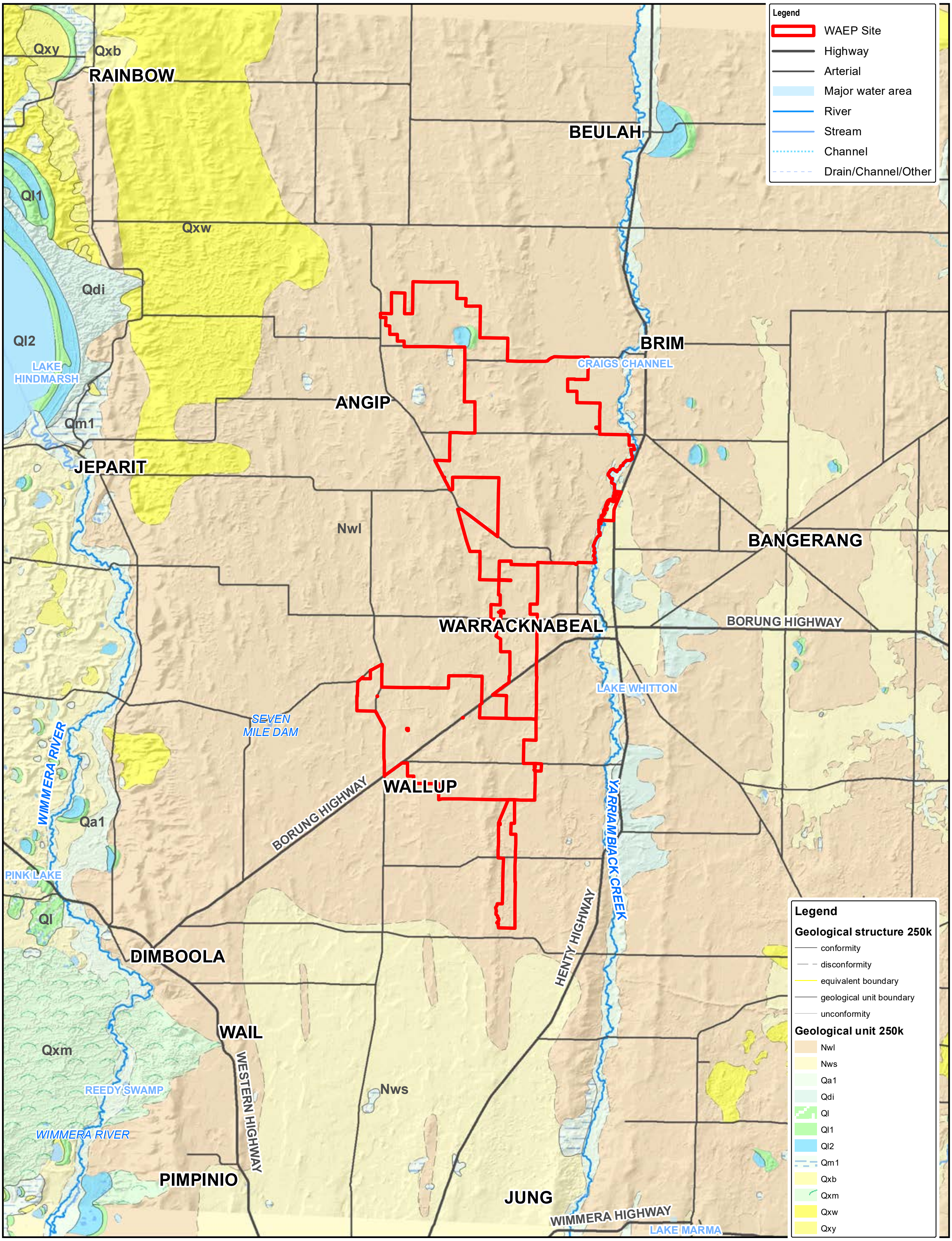
Table 5 Driller's Lithological log of Werrigar 1 (bore 102615)

From (m)	To (m)	Comments	Interpreted stratigraphy
0	0.3	Topsoil	
0.3	0.76	sub soil	
0.76	5.6	SANDY CLAY; Yellow	Loxton – Parilla Sands
5.6	6.1	SANDSTONE	
6.1	34.4	SAND	
34.4	34.9	LIMESTONE	Geera Clays | Winnambool Formation
34.9	84.1	MARL	
84.1	114.3	PYRITES	
114.3	121.9	MARL	
121.9	173.4	MARL; sandy	
173.4	176.7	CLAY; Ligneous clay with 2" to 6" bands of brown COAL	Renmark Group
176.7	190.5	CLAY and GRAVEL; white	
190.5	210.3	CLAY; greyish-white	Basement
210.3	217.3	CLAY; Yellow, mottled	

Note: Stratigraphy interpreted from the lithological descriptions.

4.3.3 Surface soils

Following the Australian Soil Classification (Isbell R., 2016), Vertosols are the dominant type in the study area. These cracking clay soils are widespread in the farming zones. While the sodosols, dense sodic subsoils, are restricted to the residential areas on the banks of the Yarriambiack Creek.



Paper Size ISO A4

0 2 4 6 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Project No. 31-12586776
Revision No. 1
Date 21/03/2023

Surface Geology

FIGURE 3

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Data source: DELWP, VicMap, 2019; DPI, Seamless Geology 250k, 2011, . Created by: lgomez

5. Waterways and drainage

5.1 Floodplain management

5.1.1 Drainage

A high level surface water desktop assessment has been undertaken to provide information on floodplain management and surface water drainage within the project area. The assessment has been carried out with review of existing elevation, interpretation of flow paths and available flood mapping data within the buffer zone of 5 km. Overland flow paths beyond the buffer zone were considered in the assessment for flow paths that crossed through the project area and to catchment outlets or points of discharge beyond the project boundary and 5 km buffer zone.

The assessment included the use of several (publicly available) data sources:

– Google maps satellite and road imagery
– VicPlan water course and water area overlays
– VicPlan contours
– Victoria Flood Database flood extents

Focusing on the project area and the 5 km buffer zone, the land generally slopes from south to north. Many of the formalised channels that previously provided local drainage in the area, have been filled and replaced by the Wimmera Mallee pipeline. Limited information is available of existing topographic conditions including any remaining formalised channels within and around the project area. Therefore runoff characteristics including the direction of flow and interaction with any remaining channel has not been included in this assessment.

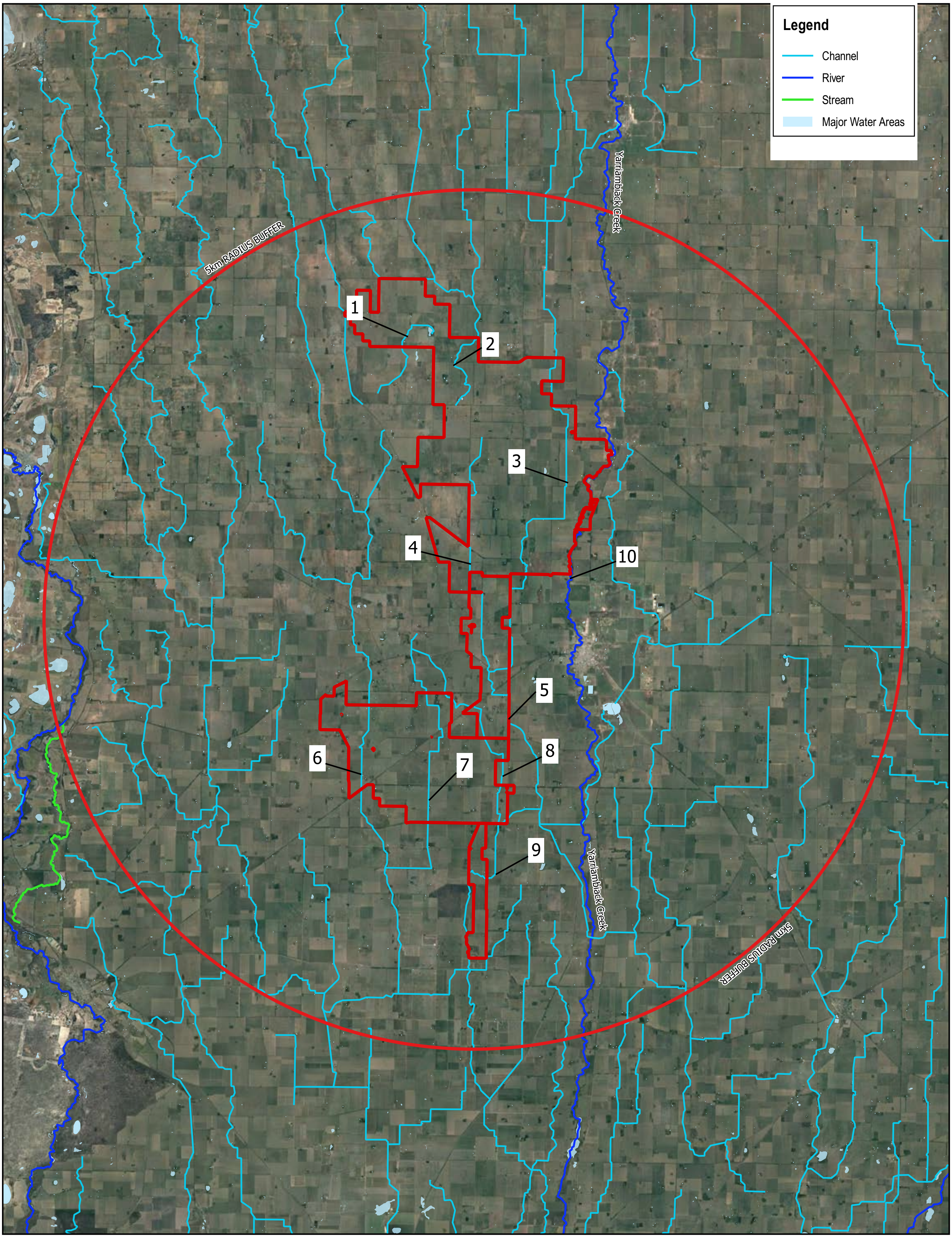
The floodplain setting of the site is on perched land between the Yarriambiack Creek to the east and Wimmera River to the west (refer Figure 4). The study area appears to interface with channels that are within the Yarriambiack Creek catchment, and there appear to be no direct interface with channels or tributary flow paths to the Wimmera River.

The Yarriambiack Creek is a distributary of the Wimmera River. It leaves the Wimmera River near Drung (approximately 20 km east of Horsham). It then flows northwards through Warracknabeal draining into Lake Coorong near Hopetoun. Flow in the waterway is intermittent and depends upon releases from the Wimmera River. The Wimmera River is located approximately 30 km due west of the study area.

Prior to any filling of the channels there were 10 main flow paths (via channels) that passed directly through the project area, that appeared to be generally flowing south to north (but this may not be the case), as shown in Figure 5 and described regionally below:

– Northern area (includes channels and drainage pipelines 1, 2, 3), where overland flow paths appear to discharge to a local depression north-west of the project boundary
– Central area (includes channels and drainage pipelines 3, 4, 5), where the flow paths appear to discharge to Yarriambiack Creek to the east of the site
– Southern area (includes channels and drainage pipelines 6, 7, 8, 9), where the flow paths appear to discharge to Yarriambiack Creek to the south east of the site.
– Yarriambiack Creek (10), which is to the east of the study area and directly interfaces with the creek over a segment of study area boundary

The catchments and flows paths in the vicinity of the project area could be better described following site section on and improved topographical information.



Paper Size ISO A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Surface Water & Identified Flow Paths

Project No. 31-12586766
Revision No. 1
Date 21/03/2023

FIGURE 4

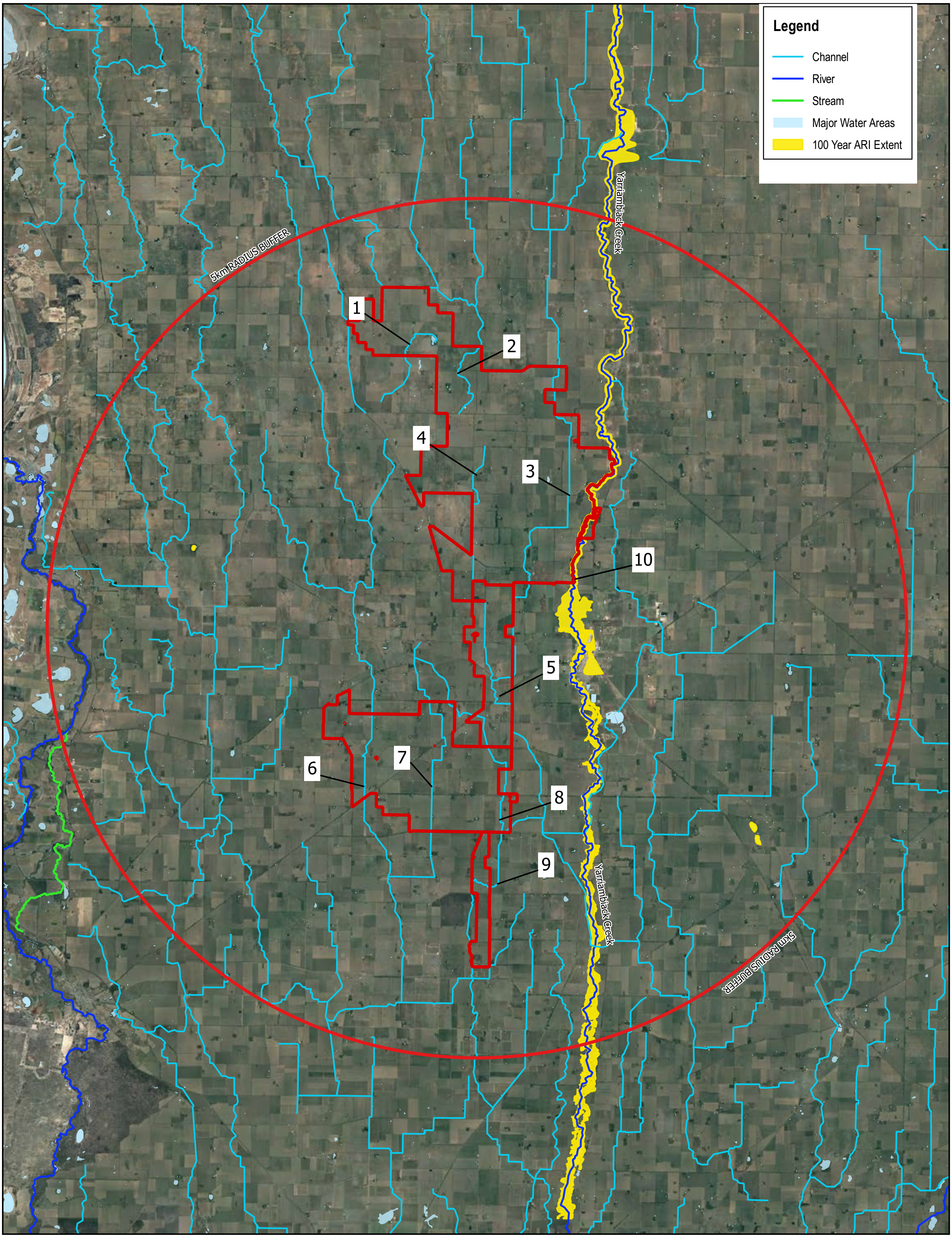
G:\31\12586776\GIS\Maps\Working\WAEP Wind Farm Surface Water Maps_Rev0_MGA 54.qgz
Print date: 11 October - 9:45

Data sources: DELWP, VicMap, 2022. Google Satellite Map, 2022. Created by: ekarlson

5.1.2 Flood extents

Flood mapping of Yarriambiack Creek indicates the flood extents are generally confined to a waterway corridor along the creek flow path, with some small segments where the flood extent widens (refer Figure 5). The mapped 1 in 100 year flood extents do not appear to indicate any direct interactions with the connecting channels or drainage pipelines, however, this may have been a limitation of the modelling approach that generated the outputs. The flood extent from Yarriambiack Creek does not appear to interface with the study area, other than where the northern boundary of the study area extends to approximately 25 m from the bank of the creek. The 1 in 100 year flood mapping in this area extends approximately 150 m from the bank of the creek.

It should be noted that in heavy local rainfall events that there would be some surface water interaction between identified flow paths, so it would be difficult to define local catchments or determine design flows estimates for any of the identified flow paths without local floodplain modelling.



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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

1 in 100 Year Flood Extent

Project No. **31-12586766**
Revision No. **1**
Date **21/03/2023**

FIGURE 5

G:\31\12586776\GIS\Maps\Working\WAEP Wind Farm Surface Water Maps_Rev0_MGA 54.qgz
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Data sources: DELWP, VicMap, 2022. Google Satellite Map, 2022. Created by: ekarlson

5.1.3 Index of Stream Condition

Three reaches of Yarriambiack Creek were included in the ISC3 and a summary has been presented in Table 6.

Table 6 Index of stream condition: Yarriambiack Creek

Parameter	Value		
Basin	Wimmera	Wimmera	Wimmera
Reach	21 Southern (near Wimmera River confluence)	22 Central	23 Northern-most (Brim – Beulah)
River	Yarriambiack Creek	Yarriambiack Creek	Yarriambiack Creek
Reach length	34.8	36.4	40.8
Hydrology	3	3	3
Physical form	8	7	7
Streamside Zone	6	6	6
Water Quality	-	5	-
Aquatic Life	-	-	-
ISC Score	26	23	18
Condition	Moderate	Poor	Very Poor

5.1.4 Ramsar Sites

No Ramsar sites were identified within the study area. The nearest Ramsar site is Lake Albacutya which lies approximately 60 km to the northwest of Warracknabeal.

5.2 Yarriambiack creek flow

An active stream flow gauging station (415241) is present on Yarriambiack Creek at Murtoa. There is an extensive flow monitoring record extending over 40 years. There has been limited flows in the creek in recent times (refer Figure 6). A flow duration curve been shown in Figure 7 which indicates a median flow of 3 ML/day.

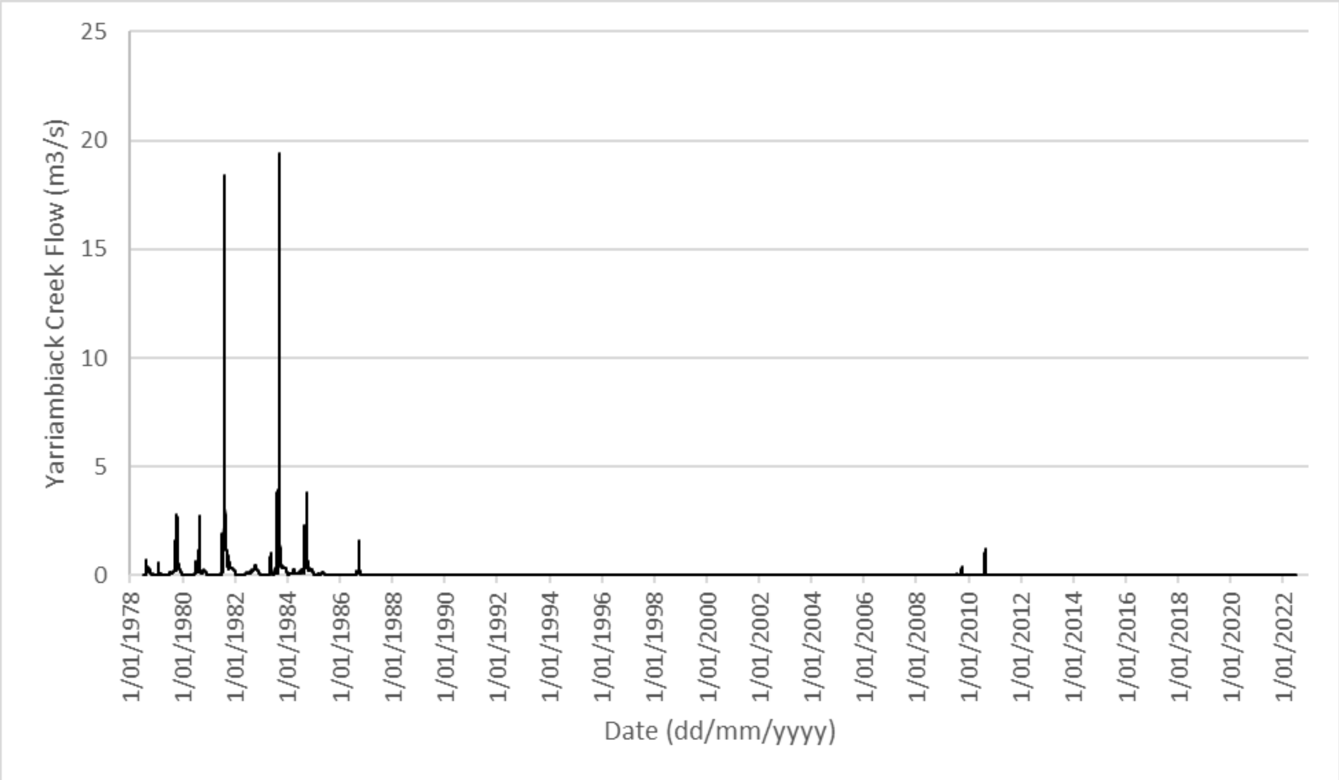


Figure 6 Yarriambiack Creek flows (at Murtoa)

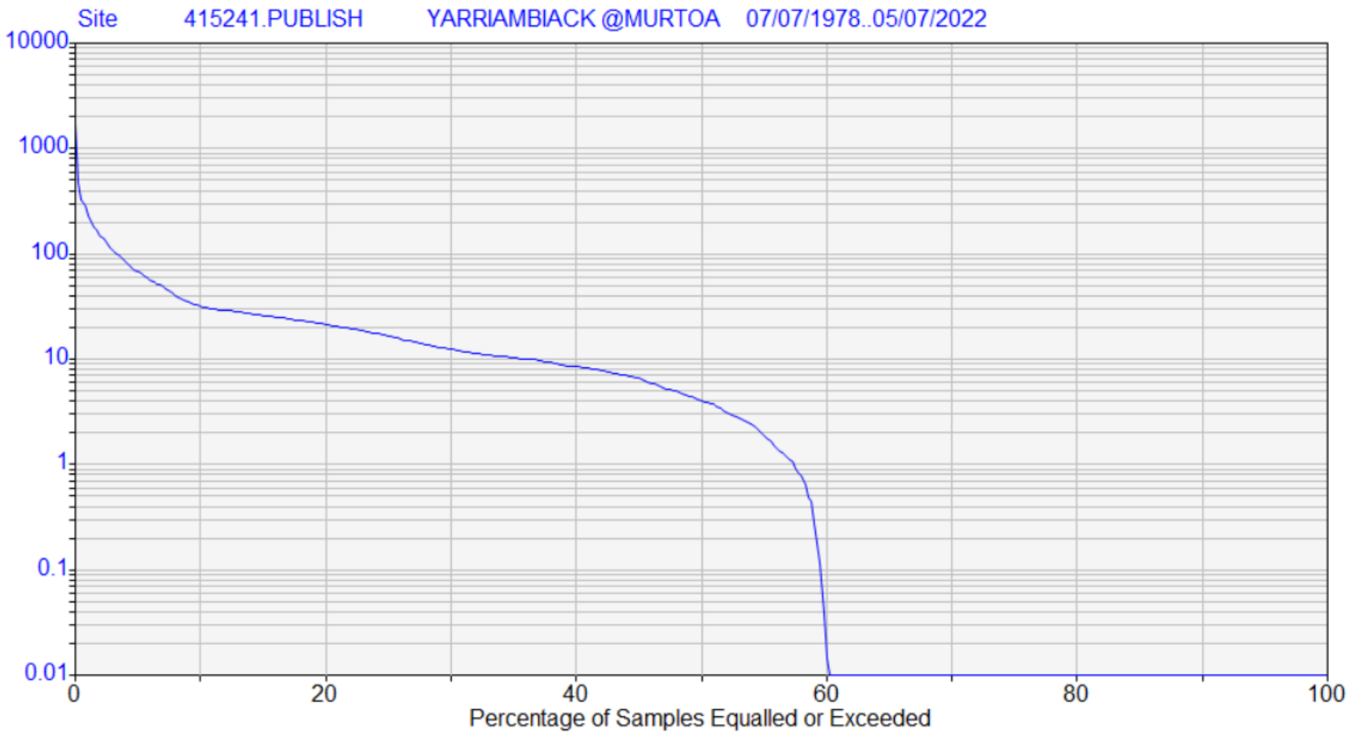


Figure 7 Yarriambiack flow duration curve (discharge in ML/day)

There is another Yarriambiack Creek gauging station 415293 at Warracknabeal township, however, there is limited data available from this site.

5.3 Water quality monitoring

5.3.1 Site specific

No site specific water quality monitoring of Yarriambiack Creek has been commissioned by WAEP.

5.3.2 Waterwatch

Waterwatch Victoria is a community engagement program which was established in the late 1990s. The program enables citizen scientists to undertake water quality monitoring and other activities to improve the health of the State's waterways.

A review of the Waterwatch map portal identified a number of active and inactive sites extending along Yarriambiack Creek between Murtoa and Hopetoun, with multiple sites in Warracknabeal. Many sites had periodical field salinity (EC) and field pH measurements.

5.4 Environmental values of waterways near the project

A list of environmental values to be protected in a waterway are defined by the *Environment Protection Act 2017* (Vic) – and listed in the Environmental Reference Standard (ERS) (EPA Victoria 2021). The environmental values are listed in Table 7.

Table 7 Environmental values of the Yarriambiack Creek

Environmental values	Note	Is environmental value use present in Yarriambiack Creek
Water dependent ecosystems	Water quality needs to be maintained to protect the integrity and biodiversity of water dependent ecosystems. This integrity and biodiversity includes – - the integrity of riparian vegetation as it contributes to the health of water dependent ecosystems and bank stability; - groundwater quality that does not adversely effect surface water ecosystems	✓
Human consumption (after appropriate treatment)	Surface water quality that is suitable for use by drinking water suppliers for delivery, after appropriate treatment, to consumers of drinking water. Water supply to townships is via Wimmera Mallee pipeline. Flows are too unreliable for potable supply use.	×
Agriculture & Irrigation	Flows are too unreliable for irrigation use.	×
Aquaculture	Flows are too unreliable for aquaculture use.	×
Human consumption of aquatic foods	Anglers may eat the fish they catch	✓
Industrial and commercial	The Creekside Hotel is on the banks of Yarriambiack Creek. However, flows are likely to be too unreliable for industrial or commercial applications.	✓
Water-based recreation (primary contact)	The creek and associated deeper waterholes can be used for fishing, canoeing, kayaking and swimming. The tracks along the creek could be visited by bushwalkers and bird watchers.	✓
Water-based recreation (secondary contact)		✓
Water-based recreation (aesthetic enjoyment)		✓

Environmental values	Note	Is environmental value use present in Yarriambiack Creek
Traditional Owner cultural values	Yarriambiack Creek is a tributary of the Wimmera River which flows within mapped areas of Aboriginal Cultural Heritage Sensitivity.	✓

Note the environmental values do not apply to water in:

– Constructed stormwater, agriculture, irrigation drains and channels
– Offstream private dams
– Water tanks
– Waste and wastewater treatment systems.

Yarriambiack Creek falls within the Murray and Western Plains segment, i.e. lowlands of the Wimmera Basin. Waterways are considered to be slightly to moderately modified.

6. Hydrogeology

6.1 Identified aquifers

Within the stratigraphic profile there are multiple aquifer systems. In general terms, the aquifers underlying the site are as follows:

– Upper system (approximately 0 m to 40 m)
  - Woorinen Formation (where saturated), Shepparton Formation (where present and saturated) and the Loxton – Parilla Sands
– Middle system (approximately 40 m to 170 m)
  - Possibly coarse grained beds within the Geera Clays or time equivalents.
  - It is noted that the lithological log of Werrigar 1 (102612) identified some limestone, however, these beds were generally thin, amidst a thick sequence of the fine grained materials (logged as marls). The development potential of this aquifer is not known, but suspected as being low.
– Deep system (>150 m)
  - Renmark Group
  - The development potential of the underlying basement is not known, but suspected as being low.

Owing to the depth of occurrence of the middle and deeper aquifer systems, they are less likely to interact with the project and therefore the focus of the hydrogeological reporting in subsequent sections has been the upper system.

6.2 Level of confinement

The shallow aquifer system represents the regional water table, and is considered to lie within the Loxton – Parilla Sands. The Woorinen Formation aeolian sediments are generally very thin and unsaturated, however, in GHD's experience some perching may occur above the underlying regional water table.

The Renmark Formation is interpreted to be confined from the upper aquifer system by the intervening fine grained materials.

6.3 Groundwater management

6.3.1 Background to resource management

DELWP has recognised areas of intensive groundwater use throughout Victoria. The principal management unit for groundwater resources in Victoria is the Groundwater Management Unit or GMU. A GMU may be a Groundwater Management Area (GMA), a Water Supply Protection Area (WSPA) or an Unincorporated Area. An Unincorporated Area is a region falling outside of a GMA or WSPA.

Under the *Water Act 1989*, the Minister for Water may declare the total volume of groundwater (and/or surface water) which may be taken in an area. This is termed the Permissible Consumptive Volume (PCV). The total volume of water allocated under the PCV became a trigger for declaration of a GMA (or WSPA).

The *Water Act 1989* requires that all persons who wish to extract groundwater (except domestic and stock users) apply for a groundwater licence. Groundwater licences are issued to protect the rights of licence holders, ensure that water is shared amongst users, and to ensure that environmental requirements are protected. The Victorian Water Register was established as a public register of all water-related entitlements.

Within WSPAs, caps or moratoriums on the issue of additional extraction licenses are often present. Owing to the implications on groundwater development, Ministerial approval, including the development of management plans, were required to convert a GMA to a WSPA. In the late 1990s approximately 50 GMAs were established across the State.

6.3.2 Relevant groundwater management area

The study area falls within the service area of the Grampians Wimmera Mallee Rural Water (GWMW), a rural water authority delegated by DELWP.

The study area does not fall within a recognised GMA. There are no moratoriums on the issue of new groundwater entitlements, however, groundwater licence applications would be subject to technical assessment and GWMW determinations under the *Water Act 1989*.

6.4 Study area groundwater use

6.4.1 Data limitations

A search of DELWP's WMIS was completed to identify groundwater bores in the area and characterise groundwater use near the proposed site, as shown in Figure 8.

The following comments are made regarding the WMIS data:

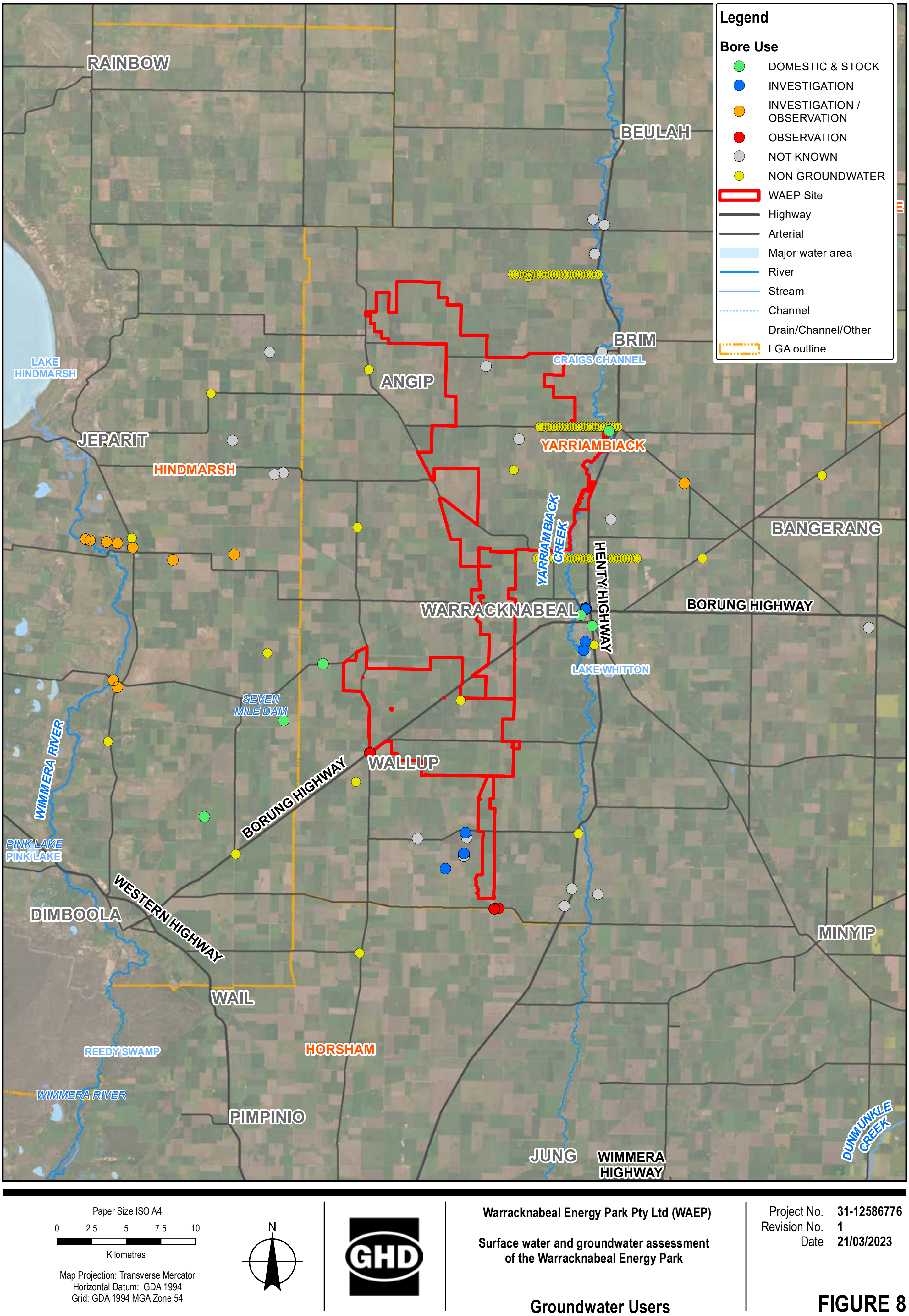
- Bores installed prior to the proclamation of the original *Water Act 1969* may not be registered as there was no mandatory requirement to licence bores prior to this date.
- WMIS does not provide information regarding the operation status of the bores.
- Bores installed without a bore construction licence are unlikely to be registered on WMIS (unless detected by later audits).
- Many bores have not been surveyed for location. Bore locations registered were often those initially proposed on the bore construction licence application. In many instances drilling contractors could not gain access to these sites and final locations often have a positional accuracy greater than ±250 m.
- The information registered on the WMIS is subject to the accuracy of the bore completion reports submitted by drilling contractors.
- Information registered on WMIS is subject to change since the completion of the bore e.g. water level information, pump setting depth, groundwater quality.
- Some information is not available on WMIS e.g. pump setting depth and bore ownership.

6.4.2 Bore use

The search identified 190 bores within an approximate 5 km radius from the outline of the study area and a breakdown of bore numbers by use type has been provided in Table 8, and shown in Figure 8.

Table 8 Summary of bore use and bore yield information

Bore Use	Count
Domestic and Stock	6
Investigation	19
Investigation/Observation	17
Non-Groundwater	112
Not Known	24
Observation	12
Total	**190**



Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Project No. 31-12586776
Revision No. 1
Date 21/03/2023

Groundwater Users

FIGURE 8

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Data source: DELWP, VicMap, 2019; DPI, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: lgomez

Only six bores with an abstractive use (stock and/or domestic) were identified. The majority of bores were drilled for investigation or observation purposes, or have a non-groundwater use. It can be seen on Figure 9 that a number of bores are located within east -west orientated transects through the study area. It is suspected that these bores have been drilled for mineral exploration purposes, e.g. identification of mineral sand deposits, which are an exploration target within the Loxton – Parilla Sands.

A total of 17 bores fall within the project boundary. Of these bores, 2 are State Observation Network (SON) bores, 14 are designated as being non groundwater and there is a single bore within an unknown use (bore 109100).

6.4.3 Bore depths

A histogram of the total bore depths for the bores within a 5 km radius of the study area has been shown in Figure 9. This indicates that the majority of bores are less than 25 m depth. Most of these being either shallow observation bores, or mineral exploration bores and developing the Loxton - Parilla Sand aquifer.

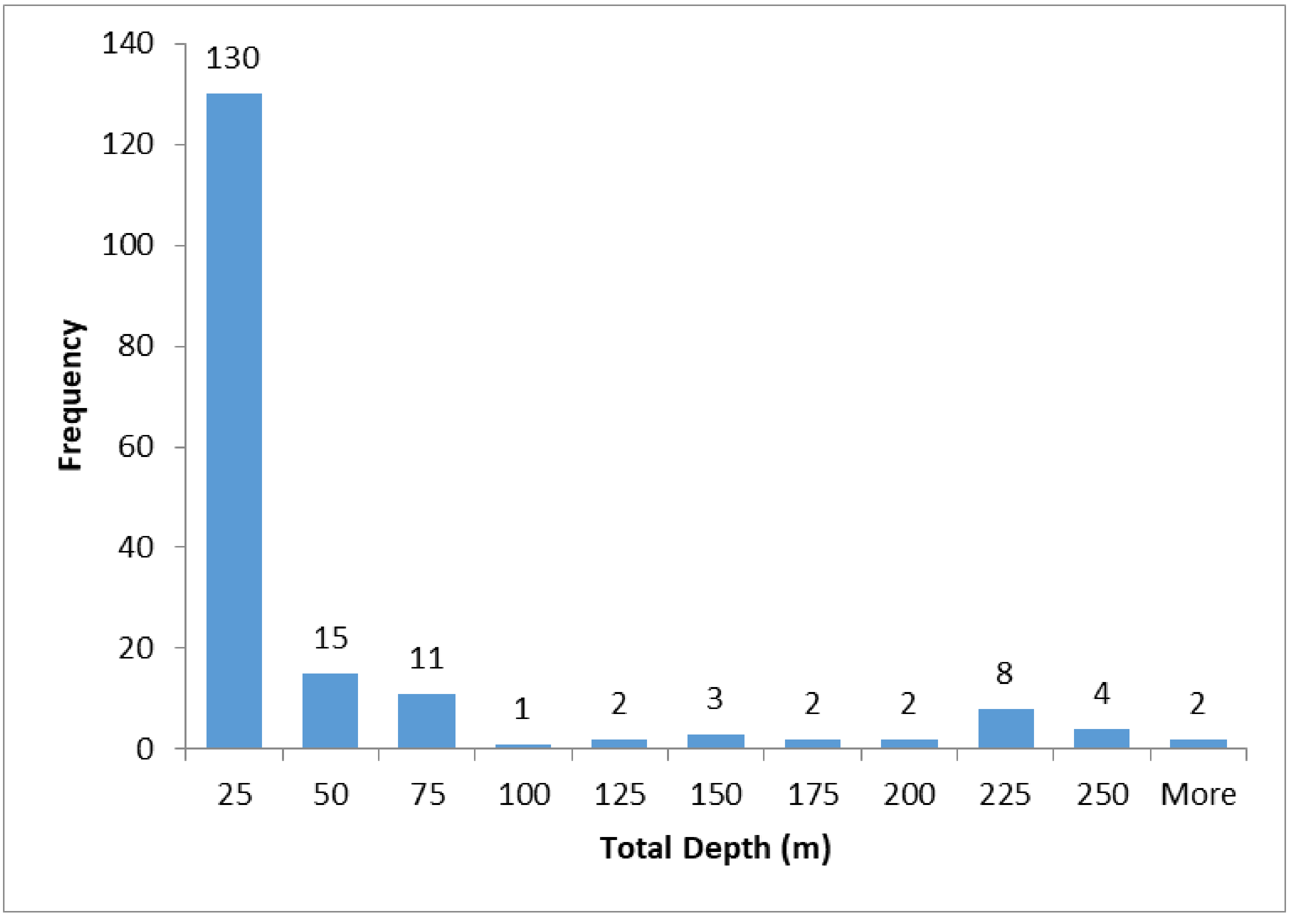


Figure 9 Bore Total Depth Histogram

6.5 Aquifer hydraulic parameters

6.5.1 Site specific

There have been no site specific aquifer investigations undertaken.

6.5.2 Regional mapping

McAuley *et al* (1992) documented a hydraulic conductivity range of the Loxton – Parilla Sands of 0.5 m/day to 5 m/day. Estimated storativity ranged between 0.005 and 0.3.

An insight into the transmissivity of the aquifers can be gained from the bore yield information. As many of the bores in the area were installed for monitoring or investigation purposes, yield information from these sites can be misleading, i.e. bore diameters tend to be small and therefore they are generally not capable of pumping high volumes.

For bores identified within the study area with yield information, a summary of yields has been provided in Table 9.

Table 9 Summary of bore yield information

Bore Use	Yield (L/s)			
	Number of bores	Minimum	Maximum	Average
Domestic and Stock	1	0.88	0.88	0.88
Investigation	0	NA	NA	NA
Investigation/Observation	0	NA	NA	NA
Non-Groundwater	0	NA	NA	NA
Not Known	2	1.18	11.37	6.28
Observation	1	5.05	5.05	5.05
Total	**4**	**0.88**	**11.37**	**4.62**

6.6 Groundwater quality

6.6.1 Classification of groundwater

The *Environment Protection Act 2017* commenced on the 1st July 2021 and specifies new objectives of the EPA and consequential amendments to the former act *Environment Protection Act 2017*. The Act changes Victoria’s focus to a prevention based approach, rather than preventing waste and pollution impacts and managing these after they have occurred. Central to the Act is the general environmental duty (GED) which requires Victorians to reduce the risk of their activities potentially harming the environment or human health through waste and pollution.

The Act introduces two subordinate instruments:

– Environment Protection Regulations (EPR)
– Environment Reference Standard (ERS)

Under section 93 of the new *Environment Protection Act 2017*, an Environmental Reference Standard (ERS) is used to assess and report on the environmental conditions throughout Victoria. The ERS:

– Identifies environmental values (human health and the environment) to be achieved or maintained in Victoria
– Specifies indicators and objectives used to measure, determine or assess whether those environmental values are being achieved, maintained, or threatened.

The ERS is not meant to represent a compliance standard, but rather has a primary function to provide an environmental assessment and reporting benchmark. The ERS contains environmental values for each element of the environment in separate parts, i.e. air, land, water (surface and groundwater), however, the different elements of the environment can impact each other and the interactions between them need to be considered.

The ERS (2020) provides that groundwater is categorised into segments, with each segment having particular identified values. The segments and their environmental values are summarised in Table 10 (and align with the SEPP Waters segments).

Table 10 Protected environmental values and groundwater segments

Environmental value	Segment (TDS mg/l)						
	A1 (0-600)	A2 (601-1,200)	B (1,201-3,100)	C (3,101-5,400)	D (5,401-7,100)	E (7,101-10,000)	F (>10,000)
Water dependent ecosystems and species	✓	✓	✓	✓	✓	✓	✓
Potable water supply (desirable)	✓						
Potable water supply (acceptable)		✓					
Potable mineral water supply	✓	✓	✓	✓			
Agriculture and irrigation (irrigation)	✓	✓	✓				
Agriculture and irrigation (stock watering)	✓	✓	✓	✓	✓	✓	
Industrial and commercial use	✓	✓	✓	✓	✓		
Water-based recreation (primary contact recreation)	✓	✓	✓	✓	✓	✓	✓
Traditional Owner cultural values	✓	✓	✓	✓	✓	✓	✓
Buildings and structures	✓	✓	✓	✓	✓	✓	✓
Geothermal properties	✓	✓	✓	✓	✓	✓	✓

Note: TDS – Total Dissolved Solids (mg/L). Source ERS (2020).

6.6.2 Groundwater quality indicators and objectives

The indicators and objectives for groundwater, for each environmental value have been summarised in Table 11. The environmental values may not apply to groundwater if:

– there is insufficient aquifer yield to sustain the environmental value, having regard to variations within the aquifer and reasonable bore development techniques to improve yield; or
– the application of that groundwater, such as for irrigation, may be a risk to the environmental values of land or the broader environment due to the soil properties; or
– the background water quality level exceeds (or is less than, in the case of indicators such as pH, dissolved oxygen and many biological indicators) the relevant objective specified in Table 11 and as a result the environmental value cannot be achieved.

Table 11 Groundwater indicators and objectives

Environmental value	Indicators	Objectives
Water dependent ecosystems and species (in surface waters)	For groundwater that discharges to surface water, the indicators are the indicators applicable to the relevant surface water as specified in Division 3 of Part 5 of this ERS	The level that ensures the groundwater does not affect receiving waters to the extent that the level of any indicator in the receiving waters: – exceeds the level of that indicator (if specified as an upper limit); or – is less than the level of that indicator (if specified as a lower limit), – specified for surface water in Division 3 of Part 5 of this ERS.
Water dependent ecosystems and species (in subterranean waters with a hydrogeological setting conducive to the presence of troglofauna and stygofauna)	Indicators that are relevant to the subterranean species of troglofauna and stygofauna, which may include TSS, salinity, toxicants in water, toxicants in sediment and dissolved oxygen	The level that ensures the groundwater quality does not adversely effect the troglofauna and stygofauna that depend on the groundwater.

Environmental value	Indicators	Objectives
Potable water supply	Indicators specified in the ADWG	Health-related guideline value for each indicator specified in the ADWG. Aesthetic guideline value for each indicator specified in the ADWG.
Potable mineral water supply	Indicators specified in the ADWG	Health guideline values for each indicator specified in the ADWG. Aesthetic guideline values for each indicator set out in the ADWG.
Agriculture and irrigation (irrigation)	Indicators specified for irrigation and water for general on-farm use in the ANZG	Level of that indicator specified in the ANZG
Agriculture and irrigation (stock watering)	Indicators specified for livestock drinking water quality in the ANZG	Level of that indicator specified in the ANZG
Industrial and commercial	Indicators specific to the particular industrial or commercial activity and their use of water	Groundwater quality that is suitable for its industrial or commercial use
Water-based recreation	E. coli	10 E. coli/100mL (if no human faecal contamination sources identified) 0 E. coli/100mL (if human faecal contamination sources identified)
	Chemical hazards, aesthetic effects	Level of indicators (where specified) and descriptions in applicable guidance, in the Recreational Water Guidelines
Buildings and structures	pH, sulphate, chloride, redox potential, salinity or any chemical substance or waste that may have a detrimental impact on the structural integrity of buildings or other structures	Groundwater that is not corrosive to or otherwise adversely effecting structures or building
Geothermal	Temperature between 30°C and 70°C.	Geothermal properties of groundwater to be maintained for current and future users of the resource

Note: ANZG - means the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)

The background water quality level is the objective for an indicator if:

- the objective is not able to be attained due to the background water quality level of that indicator; or
- the background water quality level better protects the environmental values than the objective specified in Table 11.

The ERS (2020) requires that occupational health and safety, odour and amenity also be considered, due to the fact that vapours sourced from impacted groundwater may present a potential risk to workers, and that odours or discolouration may result in degradation of overall environmental values of groundwater.

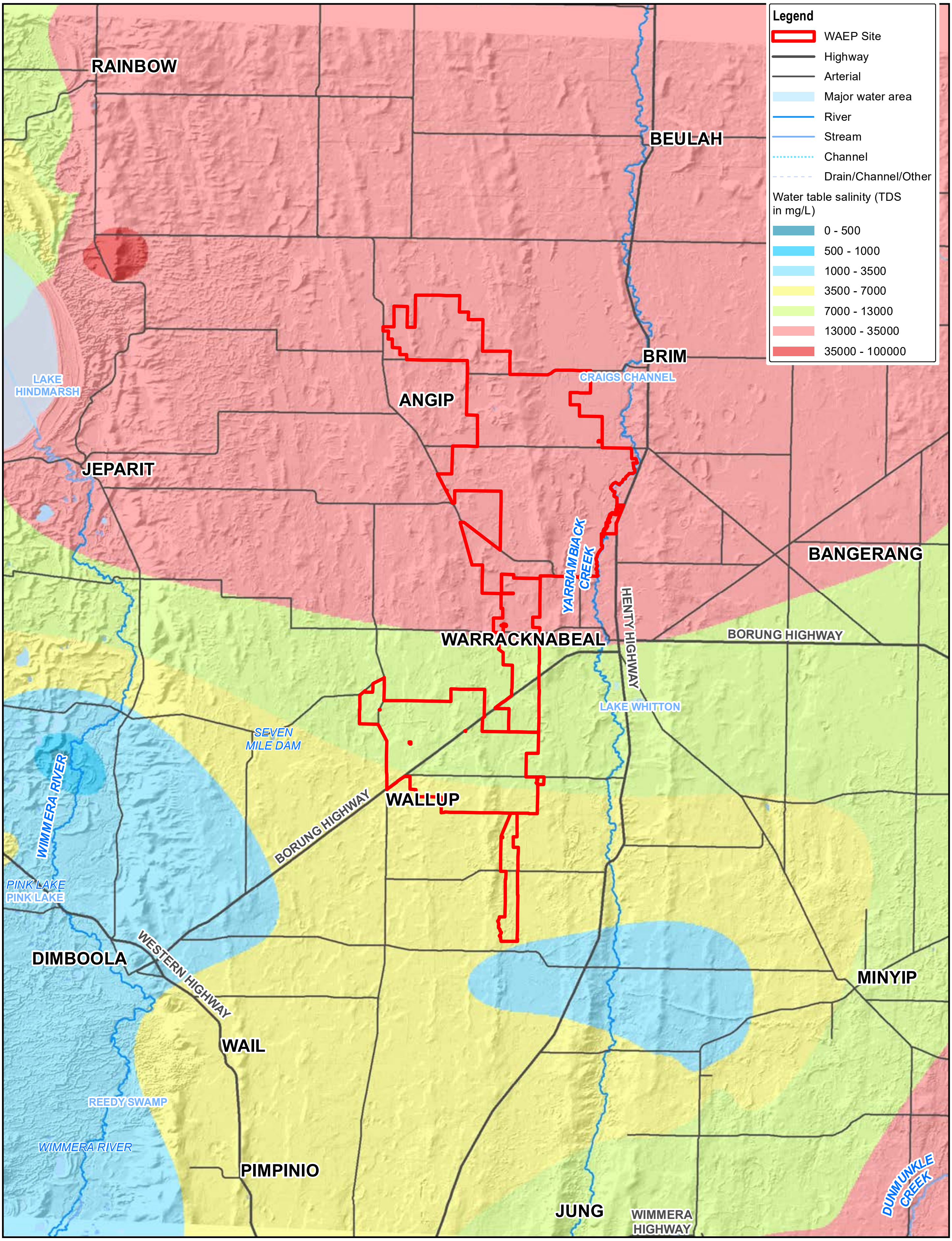
6.6.3 Background salinity

6.6.3.1 Onsite bores

There are 17 existing bores that fall within the project area (refer Figure 8) and none of these have available water quality information.

6.6.3.2 Regional mapping

The water table aquifer of the study area tends to be saline, with salinities ranging between 3,500 mg/L and 13,000 mg/L TDS. A small portion in the south-eastern corner of the site has a slightly lower salinity of 1,000 mg/L to 3,500 mg/L TDS. McAuley *et al* (1992) provided a regional interpretation of the groundwater salinity of the water table aquifer system and it has been reproduced in Figure 10.



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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GHD

Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Water Table Salinity

Project No. 31-12586776
Revision No. 1
Date 21/03/2023

FIGURE 10

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Data source: DELWP, VicMap, 2019; DPI, . Created by: lgomez

6.6.3.3 Neighbouring bores

Some bores in the study area had groundwater salinity measurements presented as either field measured Electrical Conductivity (EC) or laboratory Total Dissolved Solids (TDS). A summary of the groundwater salinity is provided in Table 12. Groundwater in the water table aquifer may be marginally fresher nearer to waterways such as Yarriambiack Creek where it could receive fresher recharge from either streambed leakage, or overbanking during flood events.

Table 12 Groundwater salinity

Parameter	Electrical Conductivity (μS/cm)	Total Dissolved Solids (mg/L)
Count	24	35
Minimum	1,120	616
Maximum	32,412	17,826
Average	16,099	8,209

6.6.4 Environmental values

A discussion of the existing environmental values of groundwater and their relevance to the proposed development has been provided Table 13.

Table 13 Discussion of environmental values

Environmental value	Existing Use	Relevance
Water dependent ecosystems and species	Yes (Yarriambiack Creek)	**Relevant** Groundwater quality must be maintained to protect aquatic ecosystems at the point of groundwater discharge. Yarriambiack Creek will be the nearest receptor, and the ERS (2020) indicates that it falls within the Murray and Western Plains segment which is a slightly to moderately modified water dependent ecosystem. Application of the 95% objective for slightly to moderately modified ecosystems is considered reasonable. Given that groundwater levels are interpreted to be deep (~20 m), the likelihood of interaction local to the project area is low, but uncertain.
Potable water supply (desirable)	No	**Not relevant** Although bores with a domestic use have been identified in the study area, groundwater is generally to saline for potable applications. In such a rural setting, there is little opportunity to access potable supply through a reticulated supply. Groundwater salinity is considered too high to support this value and therefore it is considered not relevant as an environmental value.
Potable water supply (acceptable)	No	
Potable mineral water supply	No	**Not relevant** The groundwater is not within a recognised mineral water province and is not known to display properties desirable in a mineral water e.g. spritzig or effervescence. There is a limited likelihood of groundwater being used for this purpose.
Agriculture and irrigation (irrigation)	No	**Not relevant** Bores with an irrigation use have not been identified within the study area. The regional groundwater salinity is generally to saline for irrigation applications without treatment (desalination). This is not considered to be an environmental value of groundwater locally.
Agriculture and irrigation (stock watering)	Yes	**Relevant** Nearby stock bores have been identified. The groundwater salinity locally to the project area is generally only suitable for the more salt tolerant species such as sheep and goats. Use of groundwater for livestock watering is consistent with the surrounding land uses. This is a relevant environmental value.

Environmental value	Existing Use	Relevance
Industrial and commercial use	No	**Not relevant** No existing bores with a commercial or industrial use were identified. The use of groundwater for industrial activities may be constrained by the groundwater quality (elevated salinity). However, it could be used in the future, subject to the type of industry. This is considered a relevant environmental value.
Water-based recreation (primary contact recreation)	Yes	**Relevant** There are a number of waterways near to the project including Yarriambiack Creek. The depth to groundwater based upon regional mapping suggests that the creek may be elevated above the regional water table at least locally to the project.
Traditional Owner cultural values	Yes	**Relevant** Formally recognised traditional owners in the region include the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagalk nations. No specific engagement with the local traditional owners has been undertaken as part of this desktop work. In the absence of such engagement, it has been assumed that protection of groundwater that discharges into nearby waterways is required to maintain traditional owner cultural values.
Buildings and structures	Yes	**Relevant** There are some buildings, including residential properties, located in the region, however these are assumed to have shallow foundations. Based on regional mapping, water levels tend to greater than 20 m below the surface, which suggests a limited likelihood of interaction with these structures at least locally to the project area.
Geothermal properties	No	**Not relevant** The groundwater is too shallow to have an elevated temperature and therefore this value is not considered a relevant environmental value to be protected at the site.

6.7 Groundwater potentiometry

6.7.1 Site monitoring

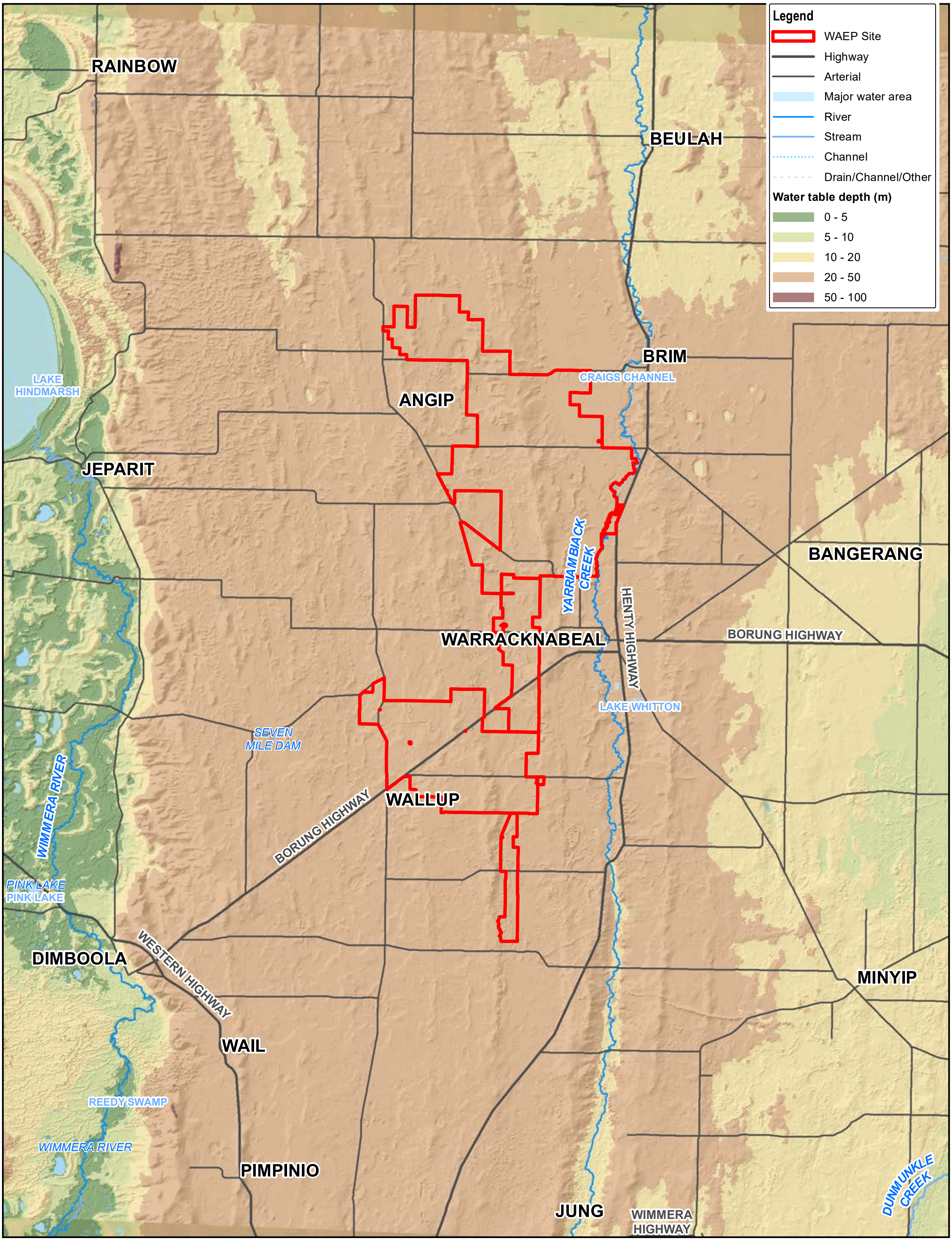
WAEP is yet to undertake any geotechnical investigations, and site specific groundwater level information is currently not available for the site.

There are 17 existing bores that fall within the project area (refer Figure 8), however none of these have available water level information.

6.7.2 Regional mapping

Regional depth to water mapping is available from DELWP and has been reproduced in Figure 11. The depth to water is interpretated to range between 20 m to 50 m below surface. This implies that the Woorinen Formation is likely to be unsaturated and that the regional water table lies within the Loxton – Parilla Sands.

Mapping indicates that the groundwater can become shallower neared to waterways such as Yarriambiack Creek. It is suspected that this is a result of recharge to groundwater from these waterways, either through streambed leakage, or overbank recharge occurring during flood events.



Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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GHD

Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Water Table Depth

Project No.	31-12586776
Revision No.	1
Date	21/03/2023

FIGURE 11

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Data source: DELWP, VicMap, 2019; DPI, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: lgomez

6.7.3 State observation bores

A search was undertaken to identify State Observation Network (SON) bores near to the project area as these can have extensive time-series water level monitoring data. Based upon records contained on the DELWP WMIS, eight (8) active SON bore were identified within the study area and their locations have been shown in Figure 12.

The bores are located in three nested groups located in the northeast, southwest and to the south of the project area. A summary of their information has been provided in Table 14 and their hydrographs have been shown in Figure 13.

The following comments are made regarding the water level monitoring responses in each of the nested sites:

- Eastern nested site (bores 101108 and 101109)

  This nested site monitors conditions in the water table aquifer (Loxton – Parilla Sands) and the deeper Renmark Group aquifer. This site is no longer active, and water level monitoring ceased in 2016, however, the monitoring response has been relatively consistent over the 30 years of available record, i.e. a slight rising water level response. Water levels are around 77 m and 79 m in the Renmark Group and Loxton – Parilla Sand aquifers respectively. This places the groundwater approximately 25 m below the surface.
- Southwestern nested site (bores 98309 and 98311)

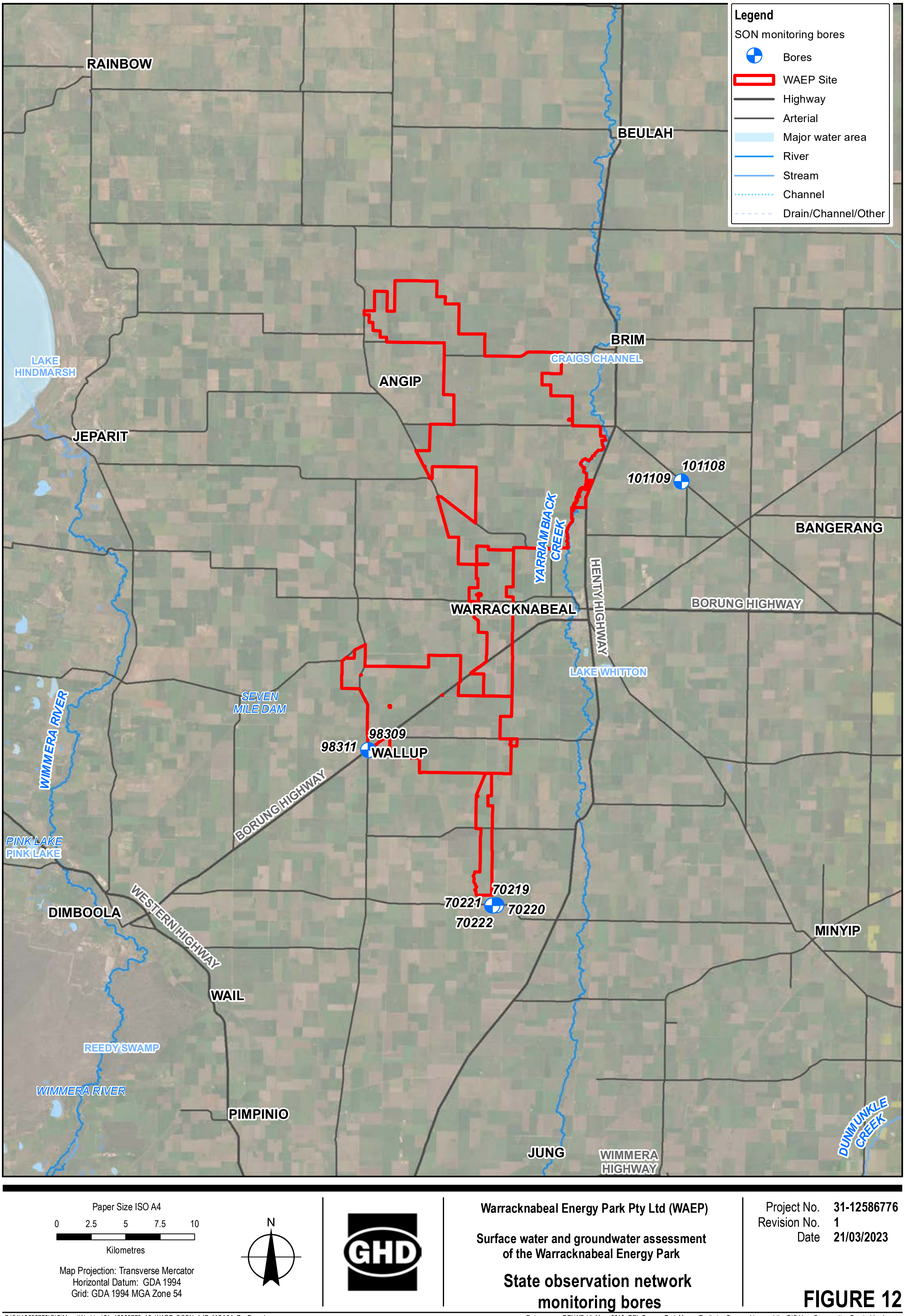
  This nested site also monitors conditions in the water table aquifer (Loxton – Parilla Sands) and the deeper Renmark Group aquifer. Bore 98309 (Renmark Group) is actively monitored, however, the shallower Loxton – Parilla Sands bore has had an anomalous monitoring response, and monitoring was discontinued in 2011. Water levels in the Renmark Group exhibit a slight rising trend, but remain approximately 30 m below the surface. The Renmark Group bore also has a dubious stepped response in the early time data.
- Southern nested site (bores 70219 to 70222)

  This site monitors conditions within the mid-Tertiary geology (Geera Clay / Winnambool Formation), and the Renmark Group. Two bores are actively monitored and indicate the depth to groundwater is approximately 30 m below surface.

Table 14 SON Bore summary

Item	Northeast Nested Site		Southwest Nest		Southern Nest			
	101108	101109	98309	98311	70219	70220	70221	70222
Easting (m)	632733.5	632738.8	610053.2	610035.2	618991.3	619309.3	619035.4	619036.1
Northing (m)	5997111	5997108	5977660	5977648.3	5966393.1	5966410	5966366.9	5966375.2
Date constructed	1991	1991	1988	1989	1976	1974	1988	1988
Total depth (m)	253	40	130	35.3	81	40	144.2	48
Elevation Top of casing (mAHD)	104.51	104.01	120.573	120.26	129.19	128.36	128.736	128.501
Elevation Ground Surface (mAHD)	103.99	103.81	119.993	119.85	128.54	128.016	128.116	128.051
Screen from	231.71	37	109	18	54	38	98	40
Screen to	234.77	39	115	30	76	40	104	43
Screen lithology	Gravel	Sand	Sand	Sand	Marl	Silts, marl	Marl	Sand
Hydrostratigraphic unit	Renmark Fm	L-P Sand	Renmark Fm	L-P Sand	Win'bool Fm	Win'bool Fm	Renmark Fm	Win'bool Fm
Monitoring record from	1992	1992	1989	1989	1976	1975	1988	1988
Monitoring record to	2016	2016	2022 (active)	2009	2011	1985	2022 (active)	2022 (active)
RLWT from	75.27	77.47	85.42	88.01	88.16	97.006	94.93	96.62
RLWT to	76.15	78.53	88.46	94.55	98.08	97.426	96.336	97.581
Number of Water level readings	116	110	133	92	196	42	173	176
Groundwater Quality TDS (mg/L)	UKN	UKN	8176.9	1844.3	12450.33	UKN	14584.8	7778.9

Note:
TOC – Top of Casing, GS – Ground Surface, TDS – Total Dissolved Solids, AMG – Australian Map Grid, AHD – Australian Height Datum, UKN - Unknown.
Coordinates GDA94 MGA55
Renmark Gp = Renmark Group (Lower Tertiary), L-P Sand = Loxton – Parilla Sand (upper Tertiary), Win'bool Fm = Winambool Formation (mid Tertiary equivalent of the Murray Group)



Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

State observation network monitoring bores

Project No. 31-12586776
Revision No. 1
Date 21/03/2023

FIGURE 12

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Data source: DELWP, VicMap, 2019; DPI, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: lgomez

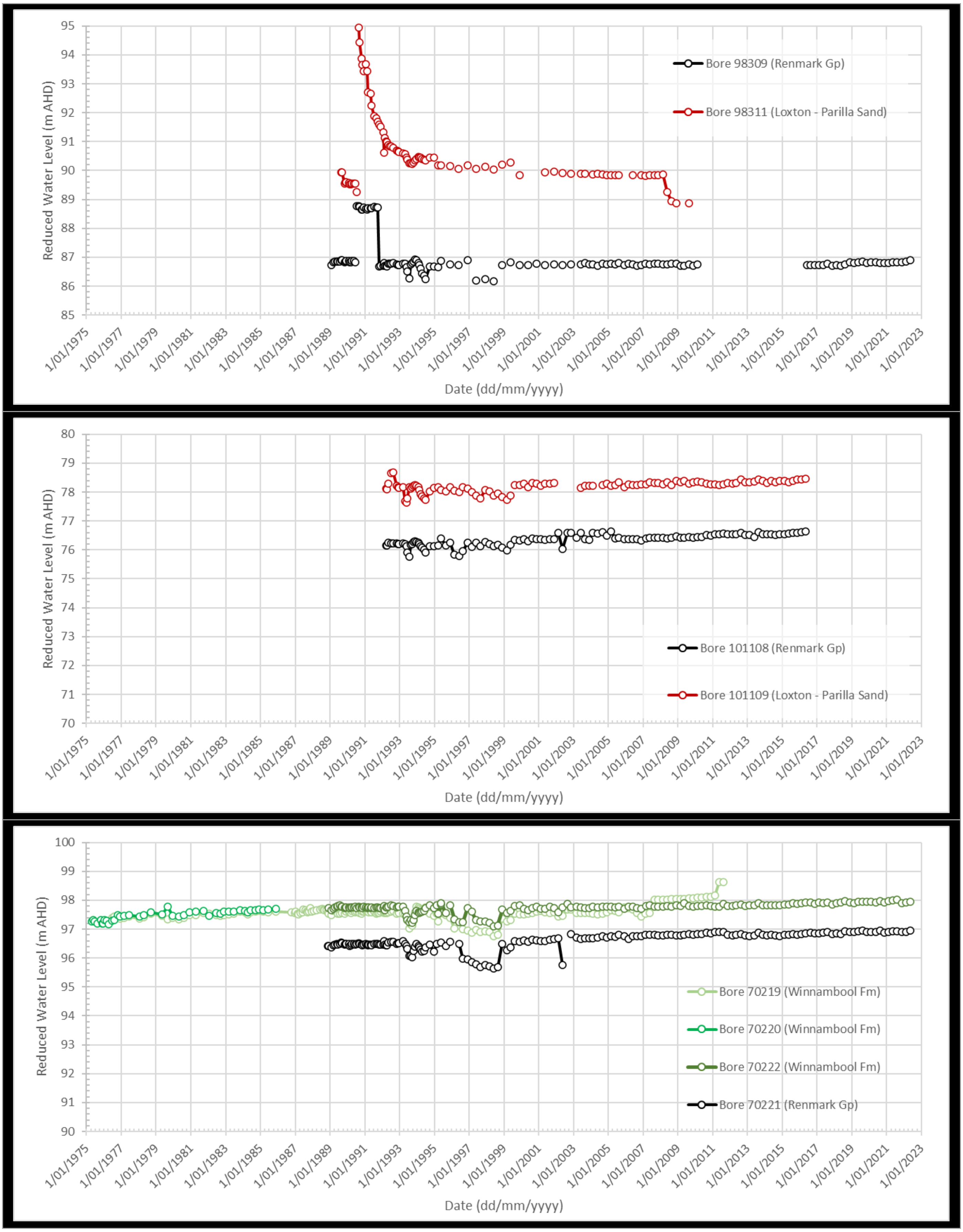


Figure 13 SON Hydrographs

6.8 Groundwater dependent ecosystems

6.8.1 Definition

A groundwater dependent ecosystem (GDE) is an ecosystem which has its species composition and natural ecological processes determined by groundwater (ARMCANZ & ANZECC, 1996). That is, they are natural ecosystems that require access to groundwater to meet all (obligatory) or some (facultative) of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services. If the availability of groundwater to GDEs is reduced, or if the quality is allowed to deteriorate, these ecosystems are impacted.

Not all GDEs draw upon groundwater directly and not all are solely reliant upon groundwater. In many cases groundwater commonly provides an important and reliable source of water to many ecosystems and can be the primary factor in controlling the distribution of ecosystem types. GDEs can depend upon the surface or subsurface expression of groundwater. In Australia, six types of GDEs have been identified:

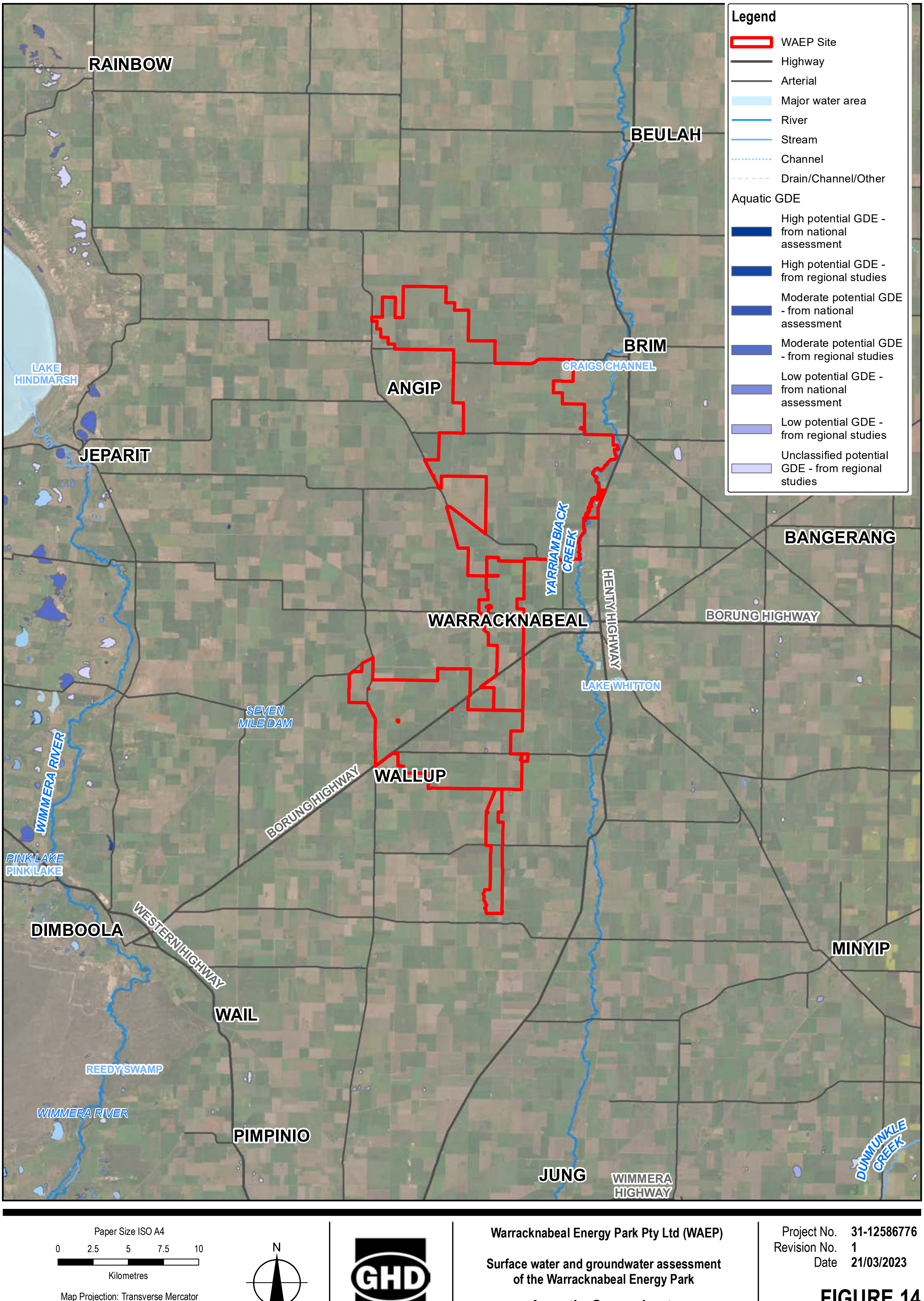
– Terrestrial vegetation that relies upon the availability of shallow groundwater. Terrestrial vegetation such as trees and woodlands may be supported seasonally or permanently by groundwater. These may comprise shallow or deep-rooted communities that use groundwater to meet some or all of their water requirements. Animals may depend on this vegetation and therefore indirectly depend on groundwater. Groundwater quality generally needs to be high to sustain vegetation growth.
– Wetlands such as paperbark swamp forests and mound springs. These sites may be permanent or ephemeral systems that receive seasonal or continuous groundwater contribution to water ponding, groundwater discharge, or shallow water tables.
– River baseflow systems where groundwater discharge provides a significant baseflow component to the river. Interaction would depend on the nature of stream bed and underlying aquifer material and the relative water level heads in the aquifer and the stream.
– Aquifer and cave ecosystems, where life exists independent of sunlight, e.g. stygofauna and troglofaunal. These ecosystems can reside within a groundwater resource.
– Terrestrial fauna (native and introduced) that rely upon groundwater as a source of drinking water
– Estuarine and near-shore marine systems, e.g. coastal mangroves, salt marshes and sea-grass beds, which rely upon the submarine discharge of groundwater

6.8.2 GDEs in study area

The National Groundwater Dependent Ecosystem Atlas (BOM, 2012) was interrogated to identify potential GDEs within the study area. Interpreted aquatic GDEs and terrestrial GDEs are shown in Figure 14 and Figure 15 respectively.

In terms of aquatic GDEs (Figure 14), that the nearest water body down gradient of the project is Yarriambiack Creek, which runs through Warracknabeal township, bordering the northern section of the site. The next closest surface water body is the Wimmera River which is further to the west of the project. Yarriambiack Creek flows intermittently and based upon the regional depth to water table, it is potentially a losing waterway locally to the project site.

Terrestrial GDEs occur within the site, however, these tend to have a moderate potential for groundwater dependence. Their main occurrence is also associated with the riparian habitats close to major waterways and drainage lines (Figure 15). The depth to groundwater would suggest that it is only accessible by more mature trees, or relying upon bank storage from flood events.



Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Aquatic Groundwater Dependent Ecosystems

Project No. 31-12586776
Revision No. 1
Date 21/03/2023

FIGURE 14

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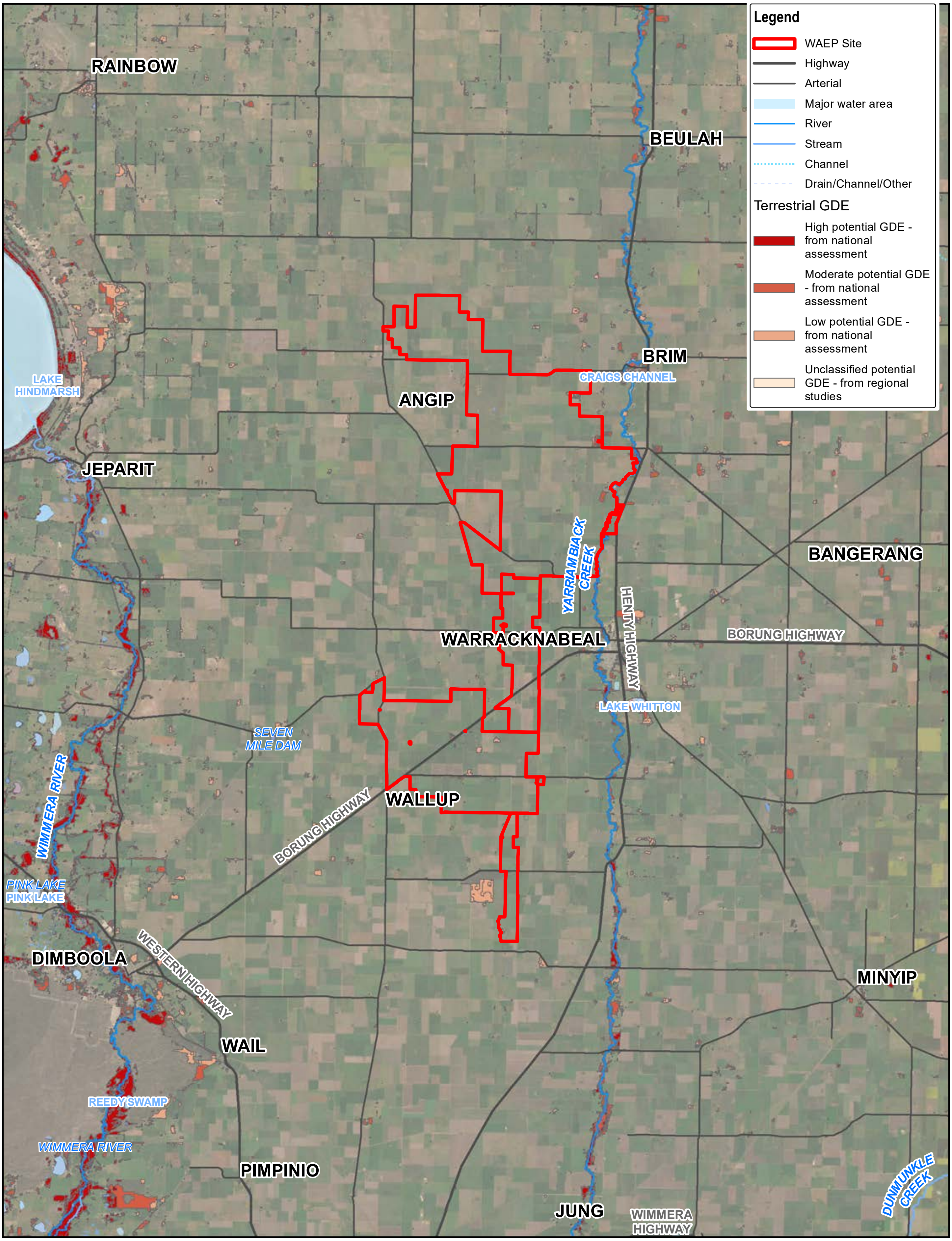
Data source: DELWP, VicMap, 2019; DPI, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: lgomez



Paper Size ISO A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Terrestrial Groundwater Dependent Ecosystems

Project No. 31-12586776
Revision No. 1
Date 21/03/2023

FIGURE 15

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Data source: DELWP, VicMap, 2019; DPI, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: lgomez

The presence of stygofauna is relatively unknown in Victoria, the study area. Factors that determine the presence include:

- Aquifers with large (mm or greater) poor spaces.
- The abundance and diversity of stygofauna typically decrease with depth below ground (i.e. generally <100 m).
- Aquifers with fresh to brackish water, generally with salinities <5,000 μS/cm.
- Aquifers rich in oxygen, i.e. >0.3 mg/L dissolved oxygen.
- Stygofauna are more abundant in areas of surface water – groundwater exchange, compared to deeper areas or those further along the groundwater flow path remote from areas of exchange or recharge.

The potential for stygofauna to be present in the study area is considered to be constrained by the nature of the aquifer materials, which can be fine grained, and the elevated groundwater salinity.

6.9 Potential acid sulfate soils

6.9.1 Definition

Acid sulphate soils are soils, sediments, unconsolidated geological material or disturbed consolidated rock mass that contain elevated concentrations of the metal sulfide. It occurs principally in the form of pyrite (iron sulphide). These soils can be rich in organics and were formed in low oxygen or anaerobic depositional environments.

The soils are stable when undisturbed or located below the water table. However, when oxygen is introduced, the sulphides oxidise to sulphate, with resultant soils having low pH and potentially high concentrations of the heavy metals.

Groundwater levels may rise as a result of recovery from construction dewatering activities, or leaching of infiltrating rainfall through the sulphate rich zones. This can result in oxidisation of materials and the mobilisation of pH and heavy metals into the environment where they can potentially impact deep-rooted vegetation, aquatic flora and fauna, and can be aggressive to reactive materials (such as concrete, steel) of foundations, underground structures (such as piles, pipes, basements) or buried services in contact with groundwater. It can also result in the discharge of acid groundwater to receiving surface water systems.

The occurrence of acid sulfate soil can be present in the form of:

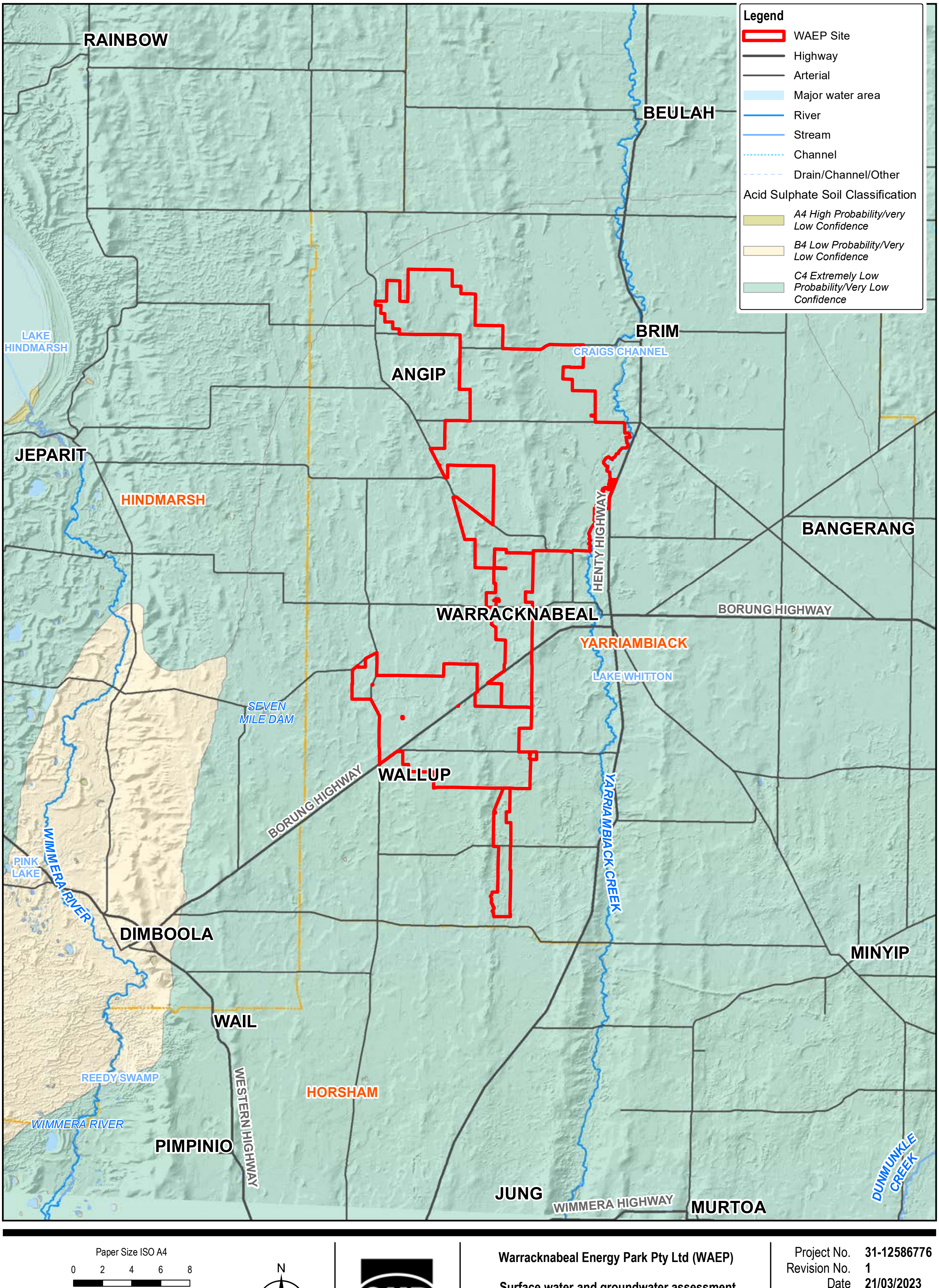
- Potential Acid Sulfate Soil (PASS) – Soil that contains unoxidised metal (iron) sulfides. This is usually in oxygen free or waterlogged conditions. When exposed to oxygen through drainage or disturbance, these soils produce sulfuric acid.
- Actual Acid Sulfate Soil (AASS) – Potential acid sulfate soil that has been exposed to oxygen and water, and has generated acidity.

There are two main pathways for the activation of acid sulfate soil to form groundwater impacts:

- Excavation of PASS soils above the water table and their management, such as acid run-off from stockpiles and treatment areas, filling, handing of spoil from excavations
- Dewatering required as part of the construction of features below the water table. Such is unlikely to be required by the project.

6.9.2 Potential in study area

CSIRO's Atlas of Australian Acid Sulphate Soils was interrogated and is shown in Figure 16. The figure shows that the site and surrounds are in an area of extremely low probability and very low confidence of acid sulphate soils occurring.



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Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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Warracknabeal Energy Park Pty Ltd (WAEP)

Surface water and groundwater assessment of the Warracknabeal Energy Park

Potential Acid Sulfate Soils

Project No. 31-12586776
Revision No. 1
Date 21/03/2023

FIGURE 16

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Data source: DELWP, VicMap; DPI, . Created by: lgomez

6.10 Conceptual hydrogeological model

A hydrogeological conceptualisation has been prepared to aid the description and understanding of the groundwater related processes that could be occurring on the site.

The conceptualisation is a tool that formalises an understanding of the major components of a hydrogeological system, their interaction and how external changes can modify the system. They can often be a highly simplified way of expressing what is known about a system, and can assist in defining (and/or testing hypotheses regarding) the critical components that make up the structures, processes and interactions, the relationships of cause and effect, and more generally, how a system works.

The information gathered during this assessment has been synthesised to generate a conceptual hydrogeological model (CHM) of the project study area. Each aspect of this model is described below and depicted diagrammatically in Figure 17. The section has been orientated east to west though the project area. The section is not to scale, as the Wimmera River lies approximately 30 km to the west of Warracknabeal.

The basal sequence of the Murray Basin sediments is the Renmark Group which comprises sands, silts, clays and coals. It is likely to lie around 70 m or more below the ground surface. It is hydraulically isolated from the Loxton – Parilla Sands aquifer by the clay rich mid Tertiary marine sequences. Further to the west of the Wimmera River, i.e. west of Dimboola, these fine grained sequences transition into the Murray Group limestone, which is an aquifer widely developed for irrigation and town water supply use (not shown on Figure 17).

The section shows the Loxton – Parilla Sands to have a thin cover of Woorinen Formation sands. Near waterways, these sediments are alluvial (rather than the aeolian dune systems of the Woorinen Formation). The Loxton – Parilla Sands are estimated to be 30 m to 50 m in thickness, and thicken westwards.

Groundwater levels are estimated to lie around 100 m AHD, or 20 m to 30 m below the ground surface. The Loxton – Parilla Sands has therefore a relatively small saturated thickness. McAuley *et al* (1992) interprets the regional groundwater flow in the water table aquifer to be north to northwest (and therefore it has not been shown in the conceptual schematic).

The water table aquifer is recharged through infiltrating rainfall occurring throughout the catchment. A smaller component of recharge is expected from leakage from Yarriambiack Creek or from flood events on this feature. As it is interpreted to be elevated above the water table, groundwater discharge is not likely to occur locally to the project, and more likely further north along regional flow paths.

Not shown on the conceptual schematic are the foundations of the towers and associated infrastructure. Services trenches are likely to be shallow (approximately 1 m) and elevated above the regional water table, however, this would be confirmed through site specific geotechnical investigations. Foundation types for wind turbines tend to be either of the following types:

– A shallow mat or ribbed beam basement
  Analogous to a slab foundation, these spreads the load of the turbine to a large ‘plate’ like shape.
  These can involve excavations as deep as 5 m to enable casting of the slab, or to provide additional weight of soil onto the foundation.
– Uplift anchors: anchors are fixed into the high strength rock.
  It is noted that within the project area the depth to rock is likely to be over 100 m
– Piles

Foundations for the project would be confirmed through geotechnical investigation, however, existing information indicates that water levels are deep and that the project is not likely to directly interact with the water table.

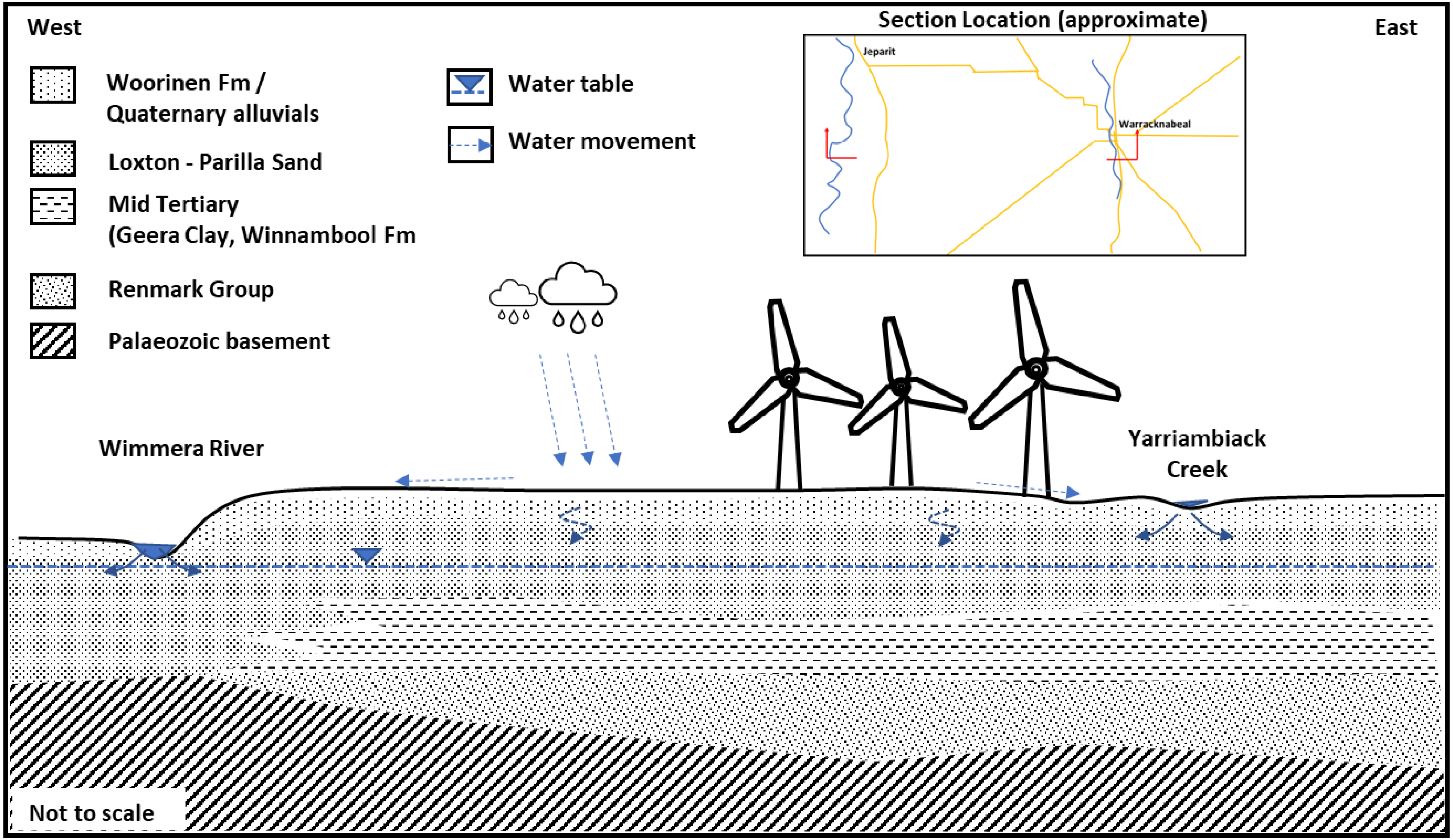

Figure 17 *Study area hydrogeological conceptualisation*

7. Proposed development

7.1 Project description

The project involves the installation of up to 230 wind turbines (assuming no major constraints), a battery plant and connecting roads and services. The current project layout comprises of two project areas, north-west and south-west of Warracknabeal. Based upon information provided by WAEP, a windfarm project will also include the following elements:

– Two internal substations (Collector Stations)
  - One of these internal substations will serve as a Terminal Station (provide connection into the electricity grid)
– Battery Energy Storage System (BESS)
  - There will be BESS at each Collector Station
– New overhead powerlines (33kV)
  - Approximately 23 km of powerline providing connection from the wind turbines to the Collector Stations
– New overhead powerlines (220kV or 500 kV)
  - Approximately 34 km of powerline providing connection between the two Collector Stations and onwards to Murra Warra Terminal Station
– Up to six permanent weather monitoring masts
– Two Operations and Maintenance (O&M) facilities
– Approximately 210 km of unsealed, all weather access tracks
– Up to four temporary concrete batching plants
– Several temporary site compounds and laydown areas

7.2 Development activities and the water environment

7.2.1 Surface water

Although most of the land within and around the project boundary is relatively flat, nearby drainage paths and the Yarriambiack Creek may cause local flooding after a significant rainfall event. Part of the north-east boundary of the project area, borders Yarriambiack Creek, which is subject to flooding during a 1 in 100 year flood event, as shown in Figure 5. Local changes to ground elevation and flow paths during construction and operation of the project have the potential to result in local flooding if appropriate flow conveyance or flood management measures are not put in place, particularly if works are being carried out adjacent to Yarriambiack Creek or local channels.

The existing conditions of the project site include a portion of the site that lies within the eastern catchment presented in Figure 5. This catchment discharges runoff to the Yarriambiack Creek, while also consisting of remaining local channels (that may still act as overland flow paths) and depressions, distributing water around properties within the catchment area. Stormwater runoff from the site area within the eastern catchment will discharge to the Yarriambiack Creek. As such, proposed project works have the potential to impact water quality and flow of the creek. Appropriate measures such as erosion and sediment control and protection of existing flow paths and channels, should be undertaken before construction works commence to minimise impacts on the receiving waterways.

7.2.2 Groundwater

The existing conditions suggest that the depth to groundwater is deep, and generally greater than 20 m below the surface. As the majority of the project is constructed above grade, there is limited direct interaction with the groundwater environment. The following is noted:

- The footprint of the project is small relative to the intake zone for the aquifer system. The project is not likely to affect groundwater recharge.
- The foundations are likely to be relatively shallow, or comprise piles. The project is not likely to require any dewatering to enable subsurface construction.
- Groundwater quality could be affected by spills of hazardous materials, e.g. refuelling activities
- Groundwater may be used as an alternate water supply for construction activities. The development of groundwater will require approvals under the *Water Act 1989*.

8. Water risk assessment

8.1 Existing conditions

A comprehensive assessment was undertaken to understand the existing conditions of the study area to inform the environmental impact assessment for the works. Existing conditions methods for surface water and groundwater are provided in Sections 5 and 6 respectively.

8.2 Avoidance and design

Relevant to this topic, the following measures have been assumed in relation to the design, construction and operation of the project to avoid and minimise impacts:

- Installation of waterway crossings that enable direct impact on waterways to be avoided
- Siting of access tracks on existing formal and informal tracks and benches where possible
- Building access tracks to follow land contours avoiding the need for significant excavations
- Building tracks and tower foundation to achieve a balance of cut and fill in trail construction, meaning that surplus spoil would not require disposal and fill would not be imported (it is noted that some material may be imported to stabilise and cap access tracks)
- All wind turbines will be located more than 100 m from Yarriambiack Creek.

8.3 Risk assessment

8.3.1 Overview of risk assessment method

An environmental risk assessment has been completed to identify environmental risks associated with construction and operation of the project. A risk-based approach is integral to an impact assessment and has the objectives to:

- Provide a consistent evaluation tool that is used for all assessments to systematically rate the key issues associated with the project
- Identify key risks associated with the project that may require further examination through the detailed impact assessment
- Inform project development and/or development of measures to avoid, mitigate and manage environmental impacts

8.3.2 Risk assessment process

The risk assessment process adopted is consistent with AS/NZS ISO 31000:2018 Risk Management Process. The following tasks were undertaken to identify, analyse and evaluate risks:

- Use existing environmental conditions and identify applicable legislation and policy to establish the context for the risk assessment
- Develop likelihood and consequence criteria and a risk matrix
- Consider construction, operational and decommissioning activities in the context of existing conditions to determine risk pathways
- Identify standard controls and requirements to mitigate identified risks
- Assign likelihood and consequence ratings for each risk to determine risk ratings considering design, proposed activities and standard mitigation

The assessment of risk combines the consequences of a threat and the likelihood of that consequence occurring, resulting in an overall risk rating. Any risk with an overall rating of medium or above requires further analysis in line with the avoid, minimise or manage hierarchy.

Risk can be defined as a combination of:

- The magnitude of potential consequences of an event occurring
- The likelihood of the consequence event occurring.

Mitigation measures which have been proposed by the proponent have been included in the ‘initial’ risk rating. The residual risk ratings for each impact include the initial mitigation measures along with those proposed to further minimise risk of impact occurring.

8.3.3 Assigning a consequence level

Consequence refers to the outcome of an event affecting an asset, value or use. Table 15 presents the consequence framework describing the consequence levels from ‘insignificant’ to ‘severe’. The consequence criteria have been developed in the form of project-wide criteria rather than discipline specific, to enable a consistent assessment of consequences across a range of potential environmental effects.

Consequence criteria is assigned based on the maximum credible consequence of the risk pathway occurring. Where uncertainty regarding consequences existed, a conservative approach to assessing risk has been adopted.

Consequence criteria considered the following characteristics:

- Spatial extent of impact
- Duration and reversibility of potential impacts
- Sensitivity and significance of the receiving environment
- Magnitude, or severity of potential impact

Each risk pathway would be assigned a level of consequence taking into account the guidance in Table 15. The consequence level, together with the likelihood level would be used to determine a risk rating in accordance with the risk matrix presented in Section 8.3.5.

Table 15   Guide to consequence levels

Level	Criteria
Insignificant Impacts are barely recognised and/or quickly recovered from. No specific remediation required.	No detectable changes or very short-term and localised. Readily reversible (insignificant) impact (<1 year for recovery). Resilient or highly disturbed receiving environment or population. No impact to native vegetation or habitat. Surface water / groundwater: No detectable changes to water levels, flow or quality with no measurable effect on assets, values or uses beyond the immediate occurrence or expression of the hazard.
Minor Hazard is perceived but has minor and typically temporary effects. Some remediation may be required.	Short-term localised detectable changes. Impact likely to be readily reversible (within 5 years for recovery). Resilient or disturbed receiving environment or population. Surface water / groundwater: Changes to water levels, flow or quality with isolated and short-term effect on assets, values or uses. Minor contamination of natural waterway or wetland occurs, but water quality remains within applicable EPA or ANZECC guidelines for existing beneficial uses. Water extraction or diversion reduces surface water flows or groundwater available for environmental uses, but with no detectable effect on dependent species or ecosystems and carried out within terms of water licence. Minor environmental contamination event (of land and/or water). Clean-up and rehabilitation may be required, but can be completed within days.
Moderate Hazard has moderate, noticeable impact, in terms of severity, duration and/ or frequency of occurrence. Moderate treatment or remediation effort may be required. Hazard event would be the subject of limited community concern.	Short or medium-term detectable changes at a number of locations within the study area. Impact likely to be medium-term and reversible (5–10 years for recovery). Undisturbed receiving environment or population. Short-term, localised impacts on critical habitats. Surface water / groundwater: Changes to water levels, flow or quality with moderate effect on assets, values or uses. Localised contamination of surface water/groundwater aquifer leading to disruption of beneficial uses as defined by ERS for weeks to months. Environmental contamination event (of land and/or water) with clean-up and rehabilitation expected to run for weeks and cost $10k–$1 million.
Major Hazard has major impact, in terms of severity, duration and/ or frequency of occurrence. Treatment or remediation effort is required. Some effects may be irreversible. Remediation of environmental contamination would require significant private and public resources. Hazard event would be the subject of widespread community concern.	Long-term changes that are significant regionally. Impact likely to be medium to long-term and potentially irreversible (> 10 years to recover). Sensitive receiving environment or population. Material impacts on critical habitats. Surface water / groundwater: Significant changes to water levels, flow or quality with assets, values or uses significantly compromised. Contamination of surface water/ groundwater aquifer leading to disruption of beneficial uses as defined by ERS (Waters) for up to one year. Environmental contamination event (of soil-land and/or water) of a magnitude that would necessitate a regional emergency management incident response. Clean-up and rehabilitation expected to run for months and/or cost $1–10 million.
Severe Hazard has critical impact, in terms of severity and/ or duration. Treatment or remediation effort is required, although some effects may be irreversible. Remediation of environmental contamination would require significant private and public resources. Hazard event would be the subject of widespread community outrage	Permanent changes that are significant at a State or Commonwealth level. Impact likely to be long-term and irreversible. Highly sensitive receiving environment or population. Significant impacts on critical habitats. Surface water / groundwater: Extensive changes to water levels, flow or quality with assets, values or uses irreversibly compromised. Contamination of surface water/ groundwater aquifer leading to disruption of beneficial uses as defined by ERS (Waters) for more than year. Environmental contamination event (of soil-land and/or water) of a magnitude that a State-level incident response is required. Incident response, clean-up and rehabilitation expected to run for years and/or cost ≥$10 million.

8.3.4 Assigning a likelihood level

'Likelihood' is the combination of the chance of an event and the chance of the identified consequence occurring. The likelihood criteria range from 'rare' where the event and consequence may occur only in exceptional circumstances to 'almost certain' where the event and consequence is expected to occur in most circumstances. Likelihoods are assigned for the maximum credible consequence according to the levels presented in Table 16.

Table 16 Guide to likelihood levels

Descriptor	Explanation
Almost Certain	The event is expected to occur in most normal circumstances. 90% - 100% chance of occurring
Likely	The event will probably occur in most normal circumstances. 70% - 90% chance of occurring
Possible	The event might occur at some time. 30% – 70% chance of occurring
Unlikely	The event could occur at some time. 5% – 30% chance of occurring
Rare	Highly unlikely, but the risk event may occur in exceptional circumstances. Less than 5% chance of occurring

8.3.5 Assigning a level of risk

Risk is defined as combination of the likelihood of an event occurring and the consequence of that event occurring. A risk rating was determined by these factors using the risk matrix, presented in Table 17.

Table 17 Risk matrix

		Consequence				
		Insignificant (5)	Minor (4)	Moderate (3)	Major (2)	Critical (1)
Likelihood	Almost Certain (A)	Medium	High	Very High	Very High	Very High
	Likely (B)	Medium	Medium	High	Very High	Very High
	Possible (C)	Low	Medium	Medium	High	Very High
	Unlikely (D)	Low	Low	Medium	High	High
	Rare (E)	Low	Low	Medium	Medium	High

When risks are rated as medium or above, the impacts associated with the risk pathway are assessed in an increasing level of detail and would prompt further exploration of potential mitigation and management actions to reduce the overall impact.

Once the risk rating has been established, some risks will need to have controls in place to reduce them to an acceptable level. Higher risk levels should take priority. Table 18 provides guidance on what steps need to be taken depending upon the risk rating.

Table 18 Risk rating acceptability

Risk level	Description
Very High	Totally unacceptable level of risk. Controls must be put in place to reduce the risk to lower levels.
High	Generally unacceptable level of risk. Controls must be put in place to reduce the risk to lower levels or seek specific guidance from ERR.
Medium	May be acceptable provided the risk has been minimised as far as reasonably practicable.
Low	Acceptable level of risk provided the risk cannot be eliminated.

8.4 Risk register

The intent of this risk assessment is to identify the key risks of the site operations upon the surface water and groundwater environment, and inform the development of a surface water and groundwater monitoring program and/or other controls to address these risks. Specifically, this risk assessment demonstrates that these risk mitigation protocols reduce the latent risk to tolerable thresholds in line with industry norms and legislative requirements. The completed risk register has been attached as Table 19.

8.4.1 Surface water

The surface water risks associated with flooding or impacting the downstream receiving waterway environments are generally low. The key potential risks identified included:

- Changes to overland flow paths and major drainage paths, impacting the flow and regime of downstream waterways
- Control discharge (pumping) from site sump storages to downstream receiving waterways impacting water quality
- Uncontrolled discharge, as a result of stormwater runoff from site to downstream receiving waterways impacting water quality
- Construction spills and the handling and storage on hazardous materials

8.4.2 Groundwater

Groundwater is not likely to be intersected during the construction and operation of the project. All of the risks relating to groundwater have been classified as being low.

Table 19 Water Risk register

Risk No.	Source / Activity	Pathway	Receptor	Project Phase	Existing control(s)	Comment	Post control risk analysis		Level of risk
							Likelihood	Consequence	
SW1	Construction activities	Storage and handling of hazardous materials results in contamination of surface run-off and receiving waterways	Neighbouring drainage lines (channels) and Yarriambiack Creek	Construction	·Construction environment management plan implemented. ·Spill kits and response procedures. ·A setback distance of 100 m to minimise direct impacts to receiving waterways.	Ground elevation is relatively flat vegetated and pervious, it is unlikely that significant volumes of contaminated runoff would reach Yarriambiack Creek. Risk can be appropriately managed by standard construction controls such as spill kits, bunding of chemical storage areas and response procedures.	Rare (E)	Minor (4)	Low (L)
SW2	Construction activities	Erosion of soil and increased amounts of sediment in surface runoff results in contamination of runoff and receiving waterways	Neighbouring drainage lines (channels) and Yarriambiack Creek	Construction	·Construction environment management plan implemented. ·A setback distance of 100 m to minimise direct impacts to receiving waterways.	Ground elevation is relatively flat vegetated and pervious, which will likely reduce the volume of sediment reaching receiving waterways. Risk can be appropriately managed through standard construction controls such as sediment barriers.	Possible (C)	Minor (4)	Medium (M)
SW3	Operation and Maintenance activities	Storage and handling of hazardous materials results in contamination of surface run-off and receiving waterways	Neighbouring drainage lines (channels) and Yarriambiack Creek	Operation	·Operation environment management plan. ·A setback distance of 100 m to minimise direct impacts to receiving waterways.	Ground elevation is relatively flat vegetated and pervious, it is unlikely that large volumes of contaminated runoff will reach Yarriambiack Creek. Risk can be appropriately managed by standard construction controls such as spill kits, bunding of chemical storage areas and response procedures.	Rare (E)	Minor (4)	Low (L)

Risk No.	Source / Activity	Pathway	Receptor	Project Phase	Existing control(s)	Comment	Post control risk analysis		Level of risk
							Likelihood	Consequence	
SW4	Construction activities	Changes to land surface elevation and drainage paths resulting in localised flooding/reduction in runoff after a rainfall event	Local ground surface. Neighbouring drainage lines (channels) and Yarriambiack Creek	Construction	·Construction environment management plan implemented. Design of infrastructure to ensure stream flows are not altered or restricted.	If local drainage paths that discharge water to Yarriambiack Creek are disrupted, the flow and regime of the Creek may be impacted.	Possible (C)	Minor (4)	Medium (M)
SW5	Construction activities	Controlled pumping of surface water on site (from sumps) discharging to receiving waterways	Neighbouring drainage lines (channels) and Yarriambiack Creek	Construction	·Construction environment management plan implemented.	Discharge of wastewater from site must be conducted in accordance with EPA Publication 1834 (2020).	Unlikely (D)	Minor (4)	Low (L)
SW6	Operation and Maintenance activities	Battery storage - Fire results in spillage of hazards materials within batteries to migrate to the water table	·Nearby waterways ·GDEs	Operation	·Battery storage facilities typically have rigorous fire and emergency management response plans (e.g. bushfires, design of layout and fire fighting controls).		Rare (E)	Minor (4)	Low (L)
GW1	Construction activities	Storage and handling of hazardous materials results in contamination of underlying groundwater	·Nearby groundwater users. ·GDEs	Construction	·Construction environment management plan implemented. ·Spill kits and response procedures.	·Significant depth to water makes aquifer less sensitive to contamination events. ·Very few existing groundwater users identified. ·Risk can be appropriately managed by standard construction controls such as spill kits, bunding of chemical storage areas and response procedures.	Rare €	Minor (4)	Low (L)

Risk No.	Source / Activity	Pathway	Receptor	Project Phase	Existing control(s)	Comment	Post control risk analysis		Level of risk
							Likelihood	Consequence	
GW2	Operation and Maintenance activities	Storage and handling of hazardous materials results in contamination of underlying groundwater	·Nearby groundwater users. ·GDEs	Operation	·Operation environment management plan.	·Significant depth to water makes aquifer less sensitive to contamination events. ·Very few existing groundwater users identified. ·Risk can be appropriately managed by standard construction controls such as spill kits, bunding of chemical storage areas and response procedures.	Rare (E)	Minor (4)	Low (L)
GW3	Construction activities	Use of groundwater as construction water supply) or fire fighting results in changes in groundwater level	·Nearby groundwater users. ·GDEs	Construction	·Licensing approvals required under the Water Act from the delegated rural water authority.		Rare (E)	Minor (4)	Low (L)
GW4	Construction activities	Shallow groundwater is unexpectedly encountered during the excavation of foundations of windfarm. Dewatering causes changes (declines) in groundwater level.	·Nearby groundwater users. ·GDEs	Construction		·Likely to be short term dewatering. ·Site investigations undertake to inform Windfarm design.	Rare (E)	Minor (4)	Low (L)
GW5	Operation and Maintenance activities	Battery storage - Fire results in spillage of hazards materials within batteries to migrate to the water table	·Nearby groundwater users. ·GDEs	Operation	·Battery storage facilities typically have rigorous fire and emergency management response plans (e.g. bushfires, design of layout and fire fighting controls).	·Groundwater could be used as a fire water supply. Under such a circumstance, this risk is same as GW3.	Rare (E)	Minor (4)	Low (L)

9. Impact assessment

9.1 Discussion of surface water risks

9.1.1 Assessment of construction impacts

9.1.1.1 Impact to surface water quality (risk SW01, SW02, SW03, SW05)

Description

Surface water runoff and waterways provide environmental value and should be protected from external impacts during construction and operation of nearby projects. Surface water quality should be upheld to reduce impact to receiving waterways and environments. Potential surface water quality changes may arise during construction and operation phases of the project from:

– Spillage, improper handling, storage and application of hazardous materials
– Erosion of ground surfaces and increased sediment load in runoff after a rainfall event
– Controlled pumping of surface water on (sumps) site to receiving waterways

Assessment

It is possible that construction activities generate local surface water quality impacts from spillage or improper handling and application of hazardous materials, such as the refuelling and maintenance of construction plant and equipment. The likelihood of these environment incidents is low because it would be a requirement to implement controls to manage chemicals, fuels and hazardous materials to manage these risks, e.g. construction environmental management plan (CEMP).

A hazardous material reaching a receiving water way and impacting the quality of water downstream is unlikely as the ground surface within the project area is relatively flat, vegetated and pervious. It is a reasonable expectation that if a release of hazardous material occurred to the environment, incident response procedures would likely occur promptly, such as the use of spill kits/containment and reduce the severity of the consequence. It is recommended that all hazardous materials are used and stored at an appropriate distance from major waterways such as Yarriambiack Creek. It is also recommended that a minimum setback distance of 100 m from Yarriambiack Creek is put in place throughout project works to protect the environmental value of the waterway.

Erosion of ground surfaces and increased sediment load in runoff as a result of exposed soil has the potential to impact surface water and the quality of receiving waterways. Appropriate erosion and sediment controls and measures to reduce soil disturbance should be put in place before construction begins, and monitored and maintained throughout the construction and operation phase of the project. Completing works outside of the 1 in 100 year modelled flood extent is recommended to reduce the risk of impacts to infrastructure and water quality as a result of erosion during a flood event. Extending the northern boundary, where the project area currently borders the creek, to be approximately 150 m from the bank of the creek is recommended.

Similarly, control measures for pumping water collected onsite during construction to local waterways should also be implemented and monitored to reduce the impact to surface water quality. Appropriate time between a rainfall event and pumping should be considered before discharging the water to a receiving waterways. This is to allow sediment and other contaminants to settle in an on site sump or pond. The quality of water being collected on site should be monitored to ensure that contaminants from project works are not being discharged to receiving waterways.

The implementation of a CEMP and on-going monitoring during construction would be required to identify whether surface water has been adversely impacted and an appropriate management response is required.

This risk remains valid during the operation phase of the project. However, the frequency of site visitation, volumes of hazardous materials being stored and handled, and the volume of traffic are likely to be significantly reduced compared to that occurring during the construction phase.

9.1.1.2 Impact to drainage paths and surface water runoff (risk SW04)

Description

Surface water runoff and waterways provide environmental value and should be protected from external impacts during construction and operation of nearby projects. Natural and formalised drainage paths should be upheld through out the project to reduce impacts downstream waterways. Drainage paths and ground elevation may be interrupted or compromised during the construction phase of the project as a result of excavation, access track development and construction of wind turbines and other infrastructure.

Assessment

It is possible that construction activities will result in changes to land elevation and disrupt local drainage paths that discharge surface water runoff to channels and creeks within and around the project area. The likelihood of these outcomes is possible as construction activities include works that involve excavation and infrastructure development that will alter surface elevation, and hence potentially disrupt drainage paths and channels. Although there are measures in place to manage these risks, e.g. construction environmental management plan (CEMP), there is still a risk present due to the nature of works and the requirements of the project.

Significant drainage paths and channels within each catchment should be avoided during the construction phase of the project. Commencing works away from major drainage paths will reduce the risk of local flooding on site, while also maintaining the quality and volume of surface water runoff discharging to receiving waterways such as the Yarriambiack Creek.

Appropriate control measures should be implemented if construction activities are to take place inline or congruent with local drainage paths. To reduce the risk of flooding on site, local drainage and stormwater storage should be implemented around construction areas located around drainage paths. If possible, stormwater runoff is recommended to be redirected to local channels or flow paths that discharge to their original outlets, e.g. Yarriambiack Creek. This control measure will reduce risks in relation the flow regime of channels around the project area and Yarriambiack Creek.

The implementation of a CEMP and on-going monitoring during construction would be required to identify whether local onsite flooding is occurring and if surface water runoff has been adversely impacted and if an appropriate management response is required.

9.1.2 Operation (and decommissioning)

9.1.2.1 Battery storages resulting in surface water contamination (risk SW06)

Description

Large scale battery storages represent a significant volume of hazardous material e.g. heavy metals in battery manufacture, that could result in adverse impact to surface water should there be an unexpected environmental release trigger by fire.

Assessment

Battery storages currently used in Victoria are commonly contained within shipping containers with associated infrastructure e.g. cooling, inverters (to convert DC to AC) and converters (transform AC voltage). Storages can include fire suppression systems.

This risk has been classified as being low based upon:

– Assumption that emergency response procedures would be prepared for the project operation.
– Assumption that fire suppression systems would be incorporated into the battery storage design.
– Emergency response would be relatively rapid, i.e. spills contained promptly after the incident.
– The ground surface is relatively flat, vegetated and pervious

9.2 Discussion of groundwater risks

9.2.1 Assessment of construction impacts

9.2.1.1 Impact to groundwater quality (risk GW01, GW02)

Description

Under the *Environment Protection Act 2017* and the ERS, groundwater has defined environmental values or beneficial uses depending on its salinity and groundwater quality which must be protected to preserve these identified beneficial uses. Potential groundwater quality changes may arise during construction and operation phases of the project from:

- Spillage, improper handling, storage and application of hazardous materials
- Reinjection of groundwater seepage
- Incompatibilities with construction materials, such as leaching from imported backfill, chemical additives to grouts and sealing resins
- Saline intrusion/mixing of native groundwaters of different salinity.

Assessment

It is possible that construction activities generate local groundwater quality impacts from spillage or improper handling and application of hazardous materials, such as the refuelling and maintenance of construction plant and equipment. The likelihood of these environment incidents is low because it would be a requirement to implement controls to manage chemicals, fuels and hazardous materials to manage these risks, e.g. construction environmental management plan (CEMP).

Furthermore, a hazardous material (pollutant) needs sufficient time and a pathway to access the groundwater environment. It must be able to migrate vertically from the surface through the soil profile to the water table. It is a reasonable expectation that if a release of hazardous material occurred to the environment, incident response procedures would likely occur promptly, such as the use of spill kits/containment and would reduce the severity of the consequence. Available information on the existing conditions indicates that groundwater levels are deep and therefore they are not highly vulnerable to spill events.

The implementation of a CEMP and on-going monitoring during construction would be required to identify whether groundwater has been adversely impacted and an appropriate management response is required.

This risk remains valid during the operation phase of the project. However, the frequency of site visitation, volumes of hazardous materials being stored and handled, and the volume of traffic are likely to be significantly reduced compared to that occurring during the construction phase.

9.2.1.2 Impact to existing users and depletion of groundwater resources (risk GW03)

Description

Groundwater resources may be developed for a water supply to service construction effort or used as an alternative to mains supply / carted water. Pumping from the production bore will influence groundwater levels, which could affect the operation of private bores, or nearby GDEs.

Assessment

There is increasing pressure for contractors to use alternative supplies of water for construction purposes to reduce stress on potable drinking water supplies. For example, groundwater may be considered for use for dust suppression, compaction control or concrete batching. The groundwater quality would need to be assessed to determine its suitability for such purposes, and such is outside the scope of the current impact assessment. It is noted that the Wimmera Mallee pipeline is another alternative water supply option for the project.

Any groundwater bores installed for construction water supply or permanent water supply would need to be licensed by Grampians Wimmera Mallee Water in accordance with the *Water Act 1989,* and would be subject to its licensing determinations. As part of any licensing determination, a proponent would be required to complete a technical hydrogeological assessment to support the groundwater licensing. This would include an assessment of impact to existing users, surface water flows and water availability. A groundwater supply would not be licensed unless the risks of extraction on groundwater (other users, the environment) are deemed acceptable by the licensing authority.

The lack of bores neighbouring the project with an extractive beneficial use indicates that the groundwater quality may be poor. It also suggests that the risk of such occurring is low and likely to be manageable.

9.2.1.3 Encountering unexpected shallow groundwater (risk GW04)

Description

Perched groundwater could occur where shallow coarse grained dune sediments (Woorinen Formation) are underlain by fine grained sediments within the Loxton – Parilla Sands. Deeper excavations required for the turbine towers may unexpectedly encounter groundwater that is perching above the regional water table. This may create seepage into excavations (which would requirement management itself) or potentially dewatering to provide stable and safe working conditions within excavations. Dewatering would reduce groundwater levels, which could affect the operation of private bores, or nearby GDEs.

Assessment

This risk has been classified as being low due to:

- The Proponent has advised GHD that geotechnical site investigations will be completed to characterise the ground conditions (and ground risks) associated with the project (wind turbine construction). Such investigations would provide a better understanding of the whether perched groundwater would be intersected.
- Owing to potentially small saturated thickness the volume in storage in perched aquifers is likely to be small, and flow rates likely low. Under these conditions, seepage flows are likely to be manageable by conventional methods e.g. pumping from excavation sumps.
- Nearby bores are likely to be developing the regional water table aquifer in order to achieve sufficient yields. Dewatering would be influencing water levels in the shallow perched system and therefore not influencing the operation of the deeper bores.
- Construction of excavations with short term only, i.e. occurring over a period of weeks or months. Following the cessation of construction and any associated dewatering activities, water levels in the aquifer are expected to recover.

9.2.2 Operation (and decommissioning)

The risks of the operation of the project on the groundwater are considered low and manageable.

9.2.2.1 Battery storages resulting in groundwater contamination (risk GW05)

Description

Large scale battery storages represent a significant volume of hazardous material e.g. heavy metals in battery manufacture, that could result in adverse impact to groundwater should there be an unexpected environmental release trigger by fire.

Assessment

Battery storages currently used in Victoria are commonly contained within shipping containers with associated infrastructure e.g. cooling, inverters (to convert DC to AC) and converters (transform AC voltage). Storages can include fire suppression systems.

This risk has been classified as being low based upon:

– Assumption that emergency response procedures would be prepared for the project operation.
– Assumption that fire suppression systems would be incorporated into the battery storage design.
– Emergency response would be relatively rapid, i.e. spills contained promptly after the incident.
– Interpreted depth to groundwater provides a buffer against the migration of contamination, i.e. takes time for substances to migrate to the water table.

It is noted that groundwater may be considered for development as a long term source for fire fighting. The development of groundwater resources in such instance would have the same risk profile as GW03, i.e. controls under the *Water Act 1989* are considered sufficient to mitigate against adverse impacts.

9.3 Climate change

According to DELWP and their predictive modelling, there are multiple lines of evidence that Victoria will be hotter and drier in the future.

9.3.1 Surface water

Although climate change has not been explicitly assessed within the project area, climate change effects may lead to an increased frequency and magnitude of peak flows in waterways, as the frequency of high intensity rain events are predicted to also increase.

To ensure that there are no long term flooding impacts to the project, the control measures to consider in relation to climate change are appropriate location of works away from drainage paths and where necessary, the implementation of drainage infrastructure and stormwater storage.

Given that the project area is relatively flat and the risk of flooding is low, climate change is not expected to affect the flooding risk of the project. It should be noted that overall flows and magnitudes of peak flows within Yarriambiack Creek may increase as a result of climate change. It has been recommended that the main wind farm infrastructure (turbines, substations and other buildings) be located outside of the 100 year ARI event flood extent of the Creek to protect infrastructure, and other works such as access paths and crossings be undertaken without impacting flood characteristics of the site. Underground cabling and access tracks with culverts may be located within the 100 year ARI event flood extent.

As the frequency of high intensity rain events are predicted to also increase, surface water runoff is also likely to increase, heightening the risk of erosion and sediment from soils around project infrastructure impacting water quality. Recommended controls to manage erosion and sediment will provide long term security if implemented and monitored appropriately throughout the operation of the project and the risk of impact on water quality remains low under climate change conditions.

9.3.2 Groundwater

Climate change may affect rates of recharge and the future availability of groundwater. DELWP (2020) are indicating that climate change may increase the frequency of high intensity rain events that provide significant recharge events for groundwater systems.

The Loxton – Parilla Sands is a water table aquifer and therefore influenced to the prevailing climate. However, the depth to groundwater is generally over 20 m, which would mean it being relatively insensitive, i.e. takes considerable time for recharge to migrate through the unsaturated zone to become a groundwater accession. During this time it can be transpired by plants.

Given the negligible interaction of the project on the groundwater environment, climate change is not expected to affect the risk profile.

10. Summary of mitigation measures

Once the potential impacts that require mitigation measures are identified, mitigation measures can be developed and added to the impact assessment register. Mitigation measures consider the 'mitigation hierarchy' as part of the design of mitigation measures to reduce/mitigate the significance of effects on the existing environment. As part of this process, where a mitigation measure from lower in the hierarchy is preferred, there must be justification for why controls from higher in the hierarchy cannot be applied. This mitigation hierarchy is illustrated in Figure 18.

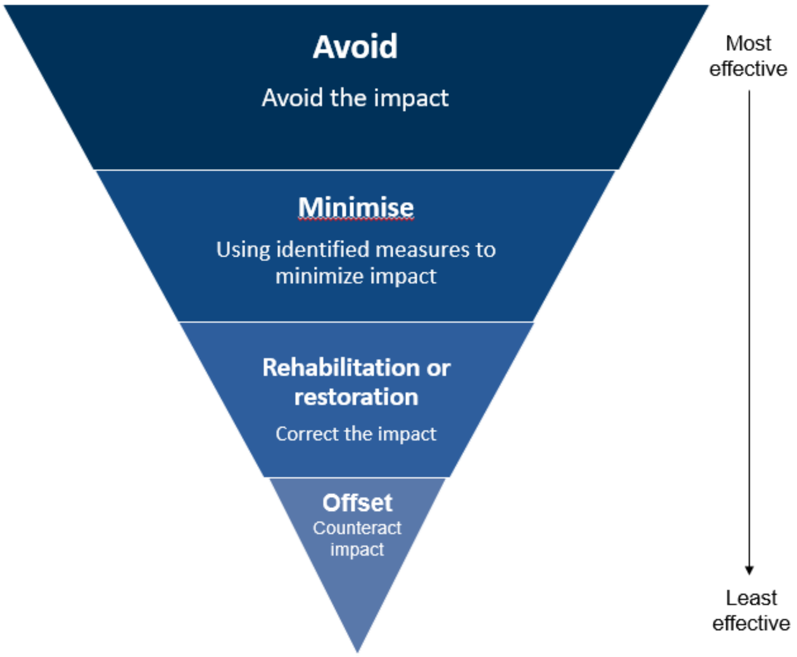

Figure 18 Mitigation hierarchy

Mitigation and contingency measures have been developed in accordance with the mitigation hierarchy and consideration of the level of potential impact. A summary has been provided in Table 20. The focus of these mitigation measures is firstly avoiding impacts where possible (building upon the avoidance measures included in the design), and secondly, implementing project-specific measures to achieve acceptable outcomes for the environment. Where it was deemed necessary, mitigation measures include monitoring of environmental performance and implementation of contingency actions should standards be exceeded.

Table 20 Mitigation measures

Measure ID	Mitigation or contingency measure	Stage
SWM01	**Undertake micro-siting prior to construction** **Objective**: Appropriate selection of waterway crossing method to protect downstream values: Avoid crossing if practical Install an elevated structure (i.e. bridge or culvert) where *Water Act* definition of a waterway is met (defined bed and banks and/or natural channel fed by spring or absorbent soil). If a culvert were to be installed to provide a means of crossing over a waterway, appropriate surface water modelling of waterway flows and impacts should be undertaken to determine appropriate sizing to minimise upstream and downstream impacts to the waterway. Install rock armouring when gully is present but no other indication of waterway as per *Water Act definition,* or if there is signs of wet/unstable soil or changes to vegetation that signal higher water concentration that is likely to impact trail surface stability Review all crossing points identified. The line of the proposed tracks to be walked by an ecologist, a tree specialist and a geomorphologist. The existing conditions of the waterway at the crossing point would be fully documented as per *Water Act* definition. Geo-referenced photographs taken of crossings that intersect the VicHydro waterway layer (where no evidence of a waterway is observed at the crossing point).	Design
SWM02	**Streamside buffers** **Objective:** To provide adequate buffer to minimise sedimentation of waterways — Apply a minimum 100 m streamside buffer to minor waterways running parallel to access tracks	Design
SWM03	**Monitoring of waterways as per the ERS** **Objective:** To monitor effectiveness of mitigation measures A waterway monitoring program would be developed in consultation with the CMA. The key potential stressor to waterways for the project is sedimentation and therefore turbidity is the key metric of interest. In addition, monitoring of macroinvertebrates would provide evidence of any longer-term Project effects. Subject to consultation outcomes with the CMA, the monitoring program would have the following key features: Monitoring scopes in alignment with the ANZG (2018) guidelines for water quality monitoring (covering such aspects as spatial extent, parameter selection, scale, duration, frequency, cost effectiveness of the monitoring program) The monitoring program would cover the construction and operations phases of the project, and be ‘adaptive’ – i.e. be responsive to the results to optimise the monitoring effort. During construction and operation, the following principal activities would be undertaken, subject to consultation with the CMA. Specific details of surface water monitoring would be incorporated into the CEMP and OEMP. *Construction:* Twice daily monitoring would be undertaken immediately upstream and downstream of waterway crossing construction where water is present at the time of construction. This monitoring would include visual observation and measurements using a handheld turbidity meter. Observations and measurements would be recorded. Should monitoring indicate that corrective or remedial actions are required at a construction site, actions would be undertaken by the construction crew (e.g., installation of hay bales, coir logs or star pickets to minimise sediment movement). The corrective actions would be recorded, including the location of the actions taken.	Construction and Operation

Measure ID	Mitigation or contingency measure	Stage
	Operation: Where monitoring detects impacts due to the project, contingency measures would be implemented such as remedial actions listed in EPA publication 1834 Civil construction, building and demolition guide (EPA 2020b) 480 Environmental Guidelines for Major Construction Sites (1996). Modifications to waterway crossing structures would also be considered where appropriate. Any corrective actions taken would be recorded including the location of actions taken.	
SWM04	**Spill management** **Objective:** Minimise the likelihood and impact of a spillage and establishing controls to contain and clean-up Follow EPA publication 1698 Liquid storage and handling guidelines (EPA 2018) Implement the CEMP to manage chemical spills and leaks: Australian Standard AS 1940- Storage and handling of flammable and combustible liquids to be adhered to. All storage and transport of chemicals will be undertaken in accordance with the relevant Australian standards. Current safety data sheets (SDS) would be kept on site wherever hazardous materials are being stored. A register of all chemicals and SDS for these chemicals would be held on site. Spill kits would be present on site during these works. All personnel would be trained in spill response procedures and in the use of spill kits. If a spill occurs works would stop immediately, and emergency procedures enacted if required. All regulated and hazardous waste would be stored in a bunded area as far as practical from the waterways. The quantity of materials being stored on site would be minimised. Machinery would be used and serviced as per manufacturer’s instructions. Vehicles would not to be washed down on-site. Plant shall not undergo maintenance or cleaning where contaminants could be released to any waters. Machinery would be refuelled at locations where the risk of environmental harm in the event of a spill is minimised, as specified in the refuelling protocol. Refuelling of machinery shall conform with the following: Occur away from waterways unless for tracked machinery and contingency plan management measures are available in the immediate area; Fuelling activity to be supervised at all times Hoses to be fitted with a stop valve at the nozzle end Machinery shall be maintained to minimise the leakage of oil, fuel, hydraulic and other fluids. During the servicing of machinery, the Contractor shall use management measures to capture and contain oils, fuels, hydraulic and other fluids so as to minimise contamination of the servicing area. Surface coating treatments would be undertaken in a manner that avoids or minimises release of chemical to the environment and contact with the public. Unless otherwise stated in the contract, no pre-coating of aggregates shall be conducted on Site. Toilet facilities utilised would be port-a-loo facility with the amenity maintained, transported and used on-site in accordance with manufacturers’ and suppliers’ specifications. All waste material would be removed from the site before removing any erosion and sediment control measures. All hazardous materials would be removed from site and disposed of appropriately	Construction

Measure ID	Mitigation or contingency measure	Stage
SWM05	**Gully erosion management and monitoring** **Objective**: To monitor effectiveness of mitigation measures Follow EPA publication 1894 Managing soil disturbance (EPA 2020c) Erosion monitoring: Photo-point monitoring of selected gully crossing points to identify gully erosion. Flow monitoring: Placement of field cameras or appropriate flow monitoring equipment at selected gully crossing to identify rainfall events which would cause water to flow in gullies or rock armouring to be overtopped. Sediment and debris observations would be made at other gully crossings during post rainfall assessments.	Operation
GWM01	**Spill Management (as per SWM 04)**	

11. Conclusions

This report makes the following conclusions:

Surface Water

- The direct interface of any infrastructure with Yarriambiack Creek should be managed by setting the minimum setback of 100 m from top of bank of creek channel, or outside of any mapped 1 in 100 year flood extent, for the main wind farm infrastructure (turbines, substations and other buildings)
- Inspection of mapped channels should be undertaken to confirm whether they have been decommissioned and filled. Where channels have not been filled, the siting of proposed infrastructure should avoid any direct interface of the various identified channels without implementing appropriate measures to reduce impact to overland flow paths and waterways
- The surface water risks associated with flooding or impacting the downstream receiving waterway environments are generally low, including:
  - Changes to overland flow paths and major drainage paths, impacting the flow and regime of downstream waterways
  - Control discharge (pumping) from site sump storages to downstream receiving waterways impacting water quality
  - Uncontrolled discharge, as a results of stormwater runoff from site to downstream receiving waterways impacting water quality
- Surface water risks associated with the project can be appropriately managed through standard construction management measures such as selective siting, bunding, spill control and sediment and erosion controls.

Groundwater

- The windfarm project is underlain by a multi-aquifer system. The Loxton – Parilla Sands is interpreted to be the regional water table aquifer. The other aquifers are too deep to interact with the proposed development.
- There is very limited groundwater development in the region, which is potentially reflected by the generally brackish to saline nature of the water table aquifer. Fresher groundwater has, however, been mapped further to the south of the project area.
- Actively monitored State Observation Network bores indicate that the water table is relatively deep, and generally greater than 20 m below the surface in the region.
- The depth to groundwater would suggest that it does not discharge to waterways locally. Yarriambiack Creek is potentially an influent or losing waterway.
- Groundwater could be used an alternate water supply to service construction, however, the groundwater quality should be assessed against its proposed uses to confirm its suitability.
- The bulk of the project is to be constructed above grade and therefore direct interaction with the groundwater environment would be limited. The groundwater risks identified on the risk register were all classified as being low.
- Relevant controls to protecting groundwater during the construction and operation of the project are considered to be:
  - Preparation and implementation of a construction environment management plan
  - Existing controls under the *Water Act 1989* regarding the requirement of a technical hydrogeological assessment to support the licensing of groundwater take and use.
- The groundwater risks associated with the project can be appropriately managed through standard construction management measures such as selective siting, bunding and spill control.

12. References

Department of Environment and Primary Industries: Index of Stream Condition. The Third Benchmark of Victorian River Condition. ISC3.

Department of Environment, Land, Water and Planning (DELWP), 2020: *Guidelines for assessing the impact of climate change on water availability in Victoria.* ISBN 978-1-76105-298-9 (pdf/online/MS word)

EPA Victoria, 2022: Groundwater sampling guidelines. Publication 669.1.

EPA Victoria, 2022: *Environment Reference Standard*. No.S245 Gazette 26 May 2021

EPA Victoria 2018 Liquid storage and handling guidelines. Publication 1698. Viewed on 1/8/2022. Available at **https://www.epa.vic.gov.au/about-epa/publications/1698**

EPA Victoria 2020a. About Stormwater. Viewed on 1/8/2022. Available at **https://www.epa.vic.gov.au/for-community/environmental-information/water/stormwater/about-stormwater**.

EPA Victoria 2020b. Civil construction, building and demolition guide. Publication 1834. Viewed on 1/8/2022. Available at **https://www.epa.vic.gov.au/about-epa/publications/1834**

EPA Victoria 2020c Managing soil disturbance. Publication 1894. Viewed on 1/8/2022. Available at **https://www.epa.vic.gov.au/about-epa/publications/1894**

EPA Victoria 2020d Managing stockpiles. Publication 1895. Viewed on 1/8/20221. Available at **https://www.epa.vic.gov.au/about-epa/publications/1895**

EPA Victoria 2020e Working within or adjacent to waterways. Publication 1896. Viewed on 1/8/2022. Available at **https://www.epa.vic.gov.au/about-epa/publications/1894**

EPA Victoria 2020f Managing truck and other vehicle movement. Publication 1897. Viewed on 1/8/2022. Available at **https://www.epa.vic.gov.au/about-epa/publications/1897**

EPA Victoria and Cardinia Shire Council (2004). Sediment Control on Unsealed Roads: A Handbook of Practical Guidelines for Improving Stormwater Quality

Isbell, R., 2016: The Australian Soil Classification. Second Edition. Australian Soil and Land Survey Handbooks Series ISBN: 978-1-4863-0465-3

McAuley, C., *et al,* Rural Water Corporation, Vic., 1992: *Horsham Hydrogeological Map (1:250,000 scale).* Australian Geological Survey Organisation, Canberra, Australia.

National Health and Medical Research Council (NHMRC), 2008: *Guidelines for managing risks in recreation waters*. ISBN Print: 1864962666

NHMRC, NRMMC (2011) *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra

National Uniform Drillers Licensing Committee (NUDLC), 2020: *'Minimum Construction Requirements for Water Bores in Australia, 4th Edition'* nominally referred to as the ARMCANZ guidelines. ISBN 978-0-646-56917-8

Standards Australia, 2004: *Australian/New Zealand Standard: AS4360* - Risk Management. Retrieved from **http://www.saiglobal.com**

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